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AID BY PROF. DR. NIELS R. FINSEN

THE GERMAN AID

BY DR. VALDEMAR BIE, LABORATORY ASSISTANT AT THE INSTITUTE

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II

EDITED BY PROF. DR. NIELS R. FINSEN

THE GERMAN EDITION PUBLISHED FROM

DR. VALDEMAR BIE

LABORATORY ASSISTANT AT THE INSTITUTE

LEIPZIG

PUBLISHING BY F. C. W. VOGEL 1901

Foreword.

This volume contains the second and third volumes of the Danish edition; two articles have been omitted because they have already been published elsewhere, namely Professor Finsen's: Light as Incitament (On the Significance of the Chemical Rays of Light for Medicine and Biology. Three Essays by N. R. Finsen, Leipzig 1899) and Professor H. Mygind's: Lupus Vulgaris Laryngis, a Clinical Investigation (Archives for Laryngology, 10th Vol.).

Dr. Th. Schüler in Berlin has shown us the kindness to correct the translation of this volume as well as that of the previous one.

Copenhagen, December 1900.

Valdemar Bie

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I. The Effects of Light on Microorganisms

by

Sophus Bang.

1) A New Method of Investigation.

Despite the numerous works of recent years on the effects of light on bacteria, the more than twenty years of work by Downes and Blunt on this subject still occupies the leading position. On the whole, their results have been confirmed; moreover, we have been enriched with a wealth of detailed knowledge. However, only a few later researchers have succeeded in introducing new guiding viewpoints, and the opinions of the individual authors diverge so widely that, when studying the relevant literature, one gets an impression approaching chaos.

This leading position of the works of Downes and Blunt deserves to be emphasized all the more because the great distance between them and the majority of their successors is usually not sufficiently emphasized. Certain imperfections must, of course, be inherent in experiments on previously unknown ground, but they made no different experimental errors than their successors

One has to be amazed at how versatile Downes and Blunt were right from the start. They not only established that both diffuse daylight and direct sunshine can inhibit all kinds of bacteria, both spores and vegetative forms, or, with prolonged exposure or greater intensity, kill them. They also demonstrated that this effect is mainly due to the most refractable rays, and they demonstrated through control experiments that it is not the warmth of the sun that is important, but its light, and that the effect occurs both when the bacteria are moist and when they are dried, although the medium surrounding the bacteria influences the time required for the light to act. They further demonstrated that the presence of oxygen is necessary, and even that the light effect is, to a certain extent, proportional to the oxygen tension They recognized the possibility that the effect of light could consist in a modification of the nutrient substrate, but they found that this was not the case in their experiments. They even considered the possibility that light could affect the metabolic products of microbes, finding that a cell-free yeast infusion loses its ability to convert cane sugar into glucose when exposed to light, and that this effect of light is also linked to the presence of free oxygen.

All of these results have been increasingly confirmed by later investigations. New findings of fundamental importance have appeared only sparsely since then. For example, Marshall Ward demonstrated the great importance of ultraviolet rays. Roux demonstrated that broth, after sufficiently long illumination, can become a less favorable medium for the germination of anthrax spores. However,

Later investigations have shown that this effect, although not without theoretical interest, is nevertheless, from a practical point of view, of subordinate importance compared to the directly killing effect on the bacteria themselves, since it only becomes apparent after very long and intense illumination. However, one cannot yet speak with complete certainty about this point, because truly quantitative determinations are still lacking. It is equally Richardson and Dieudonné are — uncertain whether right to assume that the effect of light is based on the formation of hydrogen peroxide. Arloing's attempt to prepare vaccines using light-weakened bacteria must also be mentioned as something new, which arose after Downes and Blunt.

Naturally, the later investigators improved the experimental setup in that they worked with pure cultures, whereas Downes and Blunt worked with random mixtures of bacteria from putrefactive liquids, the air, etc However important this advance is, one must not forget, on the other hand, that it was simply a consequence of the development of bacteriology, the first work by Downes and Blunt appearing in 1877 (the first relevant work using a pure culture in 1885). Nor should one overestimate the significance of this advance; for that light could kill the bacteria of a pure culture could probably be predicted with a fair degree of certainty, given that it had already been established that it could kill all possible random mixtures of bacteria, just as they occur in nature. What one should, in principle, have achieved first and foremost by using pure cultures—namely, an exact determination of the conditions under which each individual bacterial species is killed, so that one could—

The progress made through new biological insights into bacteria has, as I will explain below, so far only been made to an extremely modest extent, mainly because insufficient consideration has been given to the physical conditions.

One gets the impression that most work in this field has been carried out by more or less good bacteriologists, but by poor physicists. There are a few, but all the more fatal, errors that appear again and again in the work of various authors. Firstly, one only very rarely finds an exact indication of the light intensity used, although one would think that this factor must play the same role in investigations into the effects of light as temperature measurement does in thermodynamics. Where it is a matter of investigating the effects of sunlight or daylight, there is nothing to object to; For it is, of course, important to know that "the sun" kills this or that bacterium in so many hours, even if we are not told how strong this sun was; but I find it unforgivable when, for example, Dieudonné, to name one among many, states that an electric arc light of 900 candles can kill bacteria in a certain time, but does not state at what distance from the light this occurs, or when he does not state either the strength or the distance of the incandescent light used. Perhaps even worse is the case with all those authors who investigate the effect of individual colors. All those who use light filters (e.g., ARLOING, d'ARSONVAL & CHARRIN, BECK & SCHULTZ, BILLINGS & PEEKHAM, BOCK, DIEUDONNÉ, DOWNES & BLUNT, SERRANO FATIGATI, GAILLARD, GEISSLER, JANOWSKY, KOTLJAR, KRUSE, LAURENT, LEDOUX-LEBARD, LÜBBERT, SANTORINI, WARD)

omit information about the attenuation of light in the individual spectral regions. The most conscientious researchers determine spectroscopically which types of rays pass through the filters; but how much passes through them remains unknown, and yet they make comparisons between the different spectral regions. Such investigations are of the same value as if someone wanted to investigate whether coal or wood provides the best heat without knowing how much is used for heating

Nor has it been determined what percentage of the light penetrates the bacteria. There are only extremely few experiments where, even with the best will in the world, one can only estimate how much light penetrated into the interior of the culture, i.e., to the place where the bacteria were located. With few exceptions, the authors enclosed their cultures in glass vessels. If at least plane-parallel glass plates had been used, one could in some cases calculate the amount of light that penetrated to some extent, provided the angle of incidence, the reflection, and the absorption in both the glass and the nutrient medium were taken into account. But in reality, most researchers have used test tubes, flasks, and similar vessels that are difficult to define optically, and we are therefore faced with only unknown quantities. Of course, it is of great interest in itself to know whether, for example, For example, the effect that sunlight can have on bacteria enclosed in glass vessels is more in practical than in biological terms, since one must realize that when using glass, among other things, a very large portion of the ultraviolet rays is excluded.

The significance of this, at least from an optical-physical point of view, becomes clear from the following experiments, which I conducted with Larsen's actino-

meter. If one allows electric sparks from a Ruhmkorff to jump between two metal poles, and then moves them far enough apart that the sparks no longer jump, one can cause the sparks to jump again when the rays of an electric arc lamp fall on the negative pole, despite the increased gap. If such an apparatus was held at a distance of 30 cm from an arc of 35 amperes and 50 volts, with the rays emanating downward at an angle of 450° to the axis of the carbons, the sparks could just jump over at a certain voltage if the metal poles were 2.55 mm apart. At 2.56 mm, they no longer jump over. If a 10 mm thick quartz plate was inserted between the arc light and the spark path, this relationship did not change noticeably If, however, an opaque body (e.g., cardboard) was inserted, sparking only occurred when the poles were brought within a distance of 0.43 mm and ceased again at 0.44 mm. If, instead of cardboard, a glass plate 0.07 mm thick (i.e., about half as thick as an ordinary cover glass) was used, the poles had to be brought closer together to within 0.13 mm to produce sparks, and this again ceased at 0.44 mm. In other words, while 10 mm of quartz does not retain a measurable amount of the actinic rays in question, 0.07 mm of glass does not allow any measurable amount of them to pass through. Marshall Ward demonstrated through direct experiments, namely through spectra produced partly by glass prisms and partly by quartz prisms, that precisely this type of radiation, which passes through quartz but is absorbed by glass, has a strong bactericidal effect.

If you use glass containers for your cultures,

you must therefore be clear that you are thereby excluding a certain proportion of the rays. In this context, it is characteristic to me that Buchner, in his work on the self-purification of rivers by light, managed to kill the bacteria in a much shorter time than earlier researchers, for example, in just one hour, by exposing the germ-laden water to the sun in open containers; whether he was clear about the role the glass played in the other experiments is not clear from his work.

In certain experimental setups, refraction plays an even greater role than the absorption of the glass When numerous researchers (e.g., Arloing, Janowski, Kruse, Ledoux-Lebard, Raspe, Tizzani & Cantani, Tyndall, Marshall Ward) used a nutrient fluid in test tubes or similar glass vessels, refraction became of crucial importance. The convex surface of the glass, as is well known, refracts the rays so that they converge toward the center of the fluid, while the side portions of the fluid remain in darkness. The following experiment demonstrates how complete this darkness can be: Hold a test tube filled with water close to a piece of photographic silver chloride paper and allow the sun or arc light to shine on the glass. After a few moments, the paper becomes blackened, partly around the glass, partly along a very narrow focal line behind the center of the glass. On both sides of this line, one sees a broad stripe where the silver paper remains completely white; thus, no light effect has taken place here. Therefore, no significant light penetrated the corresponding spots inside the liquid. One can only be amazed that it was even possible to

to kill in this way. Apparently, it is only possible if the fluid is circulated, so that each individual part successively enters the illuminated area; but that the time necessary to sterilize the fluid is thereby much longer than if all parts were illuminated at once is undeniable. Therefore, we also see that the authors' time estimates are, on average, much higher than mine, insofar as it is at all possible to compare the times (see the experimental protocol, Section II). Of course, it is correct, indeed necessary, to conduct such experiments because they approximate certain naturally occurring or practically important conditions; but one must always remain aware that this investigation does not concern the speed with which a bacterium is killed by light, but the speed with which a given quantity of fluid can be sterilized under the given conditions The fact that there was uncertainty about this has led to hopeless disagreement over the time estimates given by individual researchers, and some researchers, such as Lübbert, Beck & Schultz, Raspe, and Uffelmann, have even obtained completely or partially negative results.

The experimental setup can be somewhat better if a solid nutrient medium enclosed in glass vessels is used; but here, too, the irregular refraction in unground glass plays a role as soon as one attempts to determine limiting values, as this distributes the light unevenly over the surface of the culture. Furthermore, the agar or gelatin and the substances mixed with them will themselves absorb the light, particularly its short-wave part, and the result will thus depend, among other unpredictable factors, on how deeply the bacteria are embedded in the nutrient medium.

regarding the thickness of the agar or gelatin layer. This also applies to the otherwise very useful Buchner method, which aims to illuminate a plate culture from the underside (i.e., the side in contact with the glass) in such a way that only certain parts of the culture are illuminated, while immediately adjacent parts remain protected from the light, by means of opaque letters written on the glass or in a similar manner. If, under these circumstances, an illuminated section appears sterile after a certain illumination time, one can, strictly speaking, only conclude that the illumination in question kills even those bacteria that were most protected by the agar layer. When the effect began on the bacteria that were on the side of the agar layer facing the light remains unknown This method can be used where it is important to compare the properties of different light sources, but it is less suitable for biological questions, where the primary objective is to determine the minimum killing time for a particular bacterium. In earlier investigations at Finsen's Light Institute, it was believed that the Buchner method could be improved by determining the time at which the first visible "attenuation" of the bacteria became apparent, but this was done with an unclear definition. The first visible attenuation meant that the illuminated spot, after all surviving bacteria had grown out, would appear somewhat less cloudy than the unexposed parts of the nutrient medium. However, this would occur when the light intensity (or exposure time) was just high enough to kill the bacteria in the part of the nutrient medium closest to the light source, while the light in the deeper layers of the nutrient medium was so attenuated that

weakened by absorption was that they did not die here. What was demonstrated, therefore, was not a weakening of the bacteria: only some were killed and others left alive, whereby the number of growing colonies decreased; in other words, one demonstrated not a weakening, but a "dilution." Moreover, whether a real weakening of the individual bacteria occurred is difficult to determine in this way; in any case, no proof of this has been provided so far. And the only conclusion that can be drawn from the experiment is the following: The light in question was just strong enough to penetrate a "visible" distance into a nutrient medium of the respective color and transparency, seeded with bacteria of the respective density, without losing its bactericidal properties—all factors that contribute to the result, but are difficult to keep constant or express numerically If, on the whole, so little consideration has been given to such drastic sources of error as — all those mentioned above, one should not be surprised that the results of various researchers differ so much from one another. Thus, it is hardly even possible to compare them with one another; indeed, it is sometimes difficult to understand how an individual researcher could obtain consistent results within his own series of experiments, especially when the deviations that I will demonstrate experimentally below are added to these. If the theory of the relationship of bacteria to light is to assume the place in biological science that it certainly deserves, given the role this relationship plays in the economy of nature, much greater emphasis must be placed on quantitative work than before. The fact that the first investigations in a completely new field are, by and large,

are mainly qualitative, is not surprising, and such investigations are of great importance as groundbreaking and stimulating. But one gradually reaches a point in this science, as in every other, where it becomes necessary to "weigh and measure." And the measurement here must be twofold: partly, certain effects of light can be measured using microbes, and partly, certain properties of microbes can be measured using light. Both types of measurements must be carried out, but primarily, it seems most natural to me to start with light, as the best known of these factors. Light must be the precisely weighed reagent with which we seek to measure new aspects of the bacterial lifestyle; but this only becomes possible when we take precise account of the physical conditions. An improved method of investigation is the conditio sine qua non.

The method I use

In order to achieve the most precise dosage of light, I attempted to create an experimental setup whereby the light beam encounters as few and as small obstacles as possible on its path from the light source to the bacterial body, and where the obstacles that cannot be avoided can be assessed and measured.

I believe I have found a reasonably satisfactory solution to this problem in the application of the apparatus described below, which uses as few and as simple reflecting surfaces as possible, as little absorption and refraction as possible, constant temperature, and the possibility of

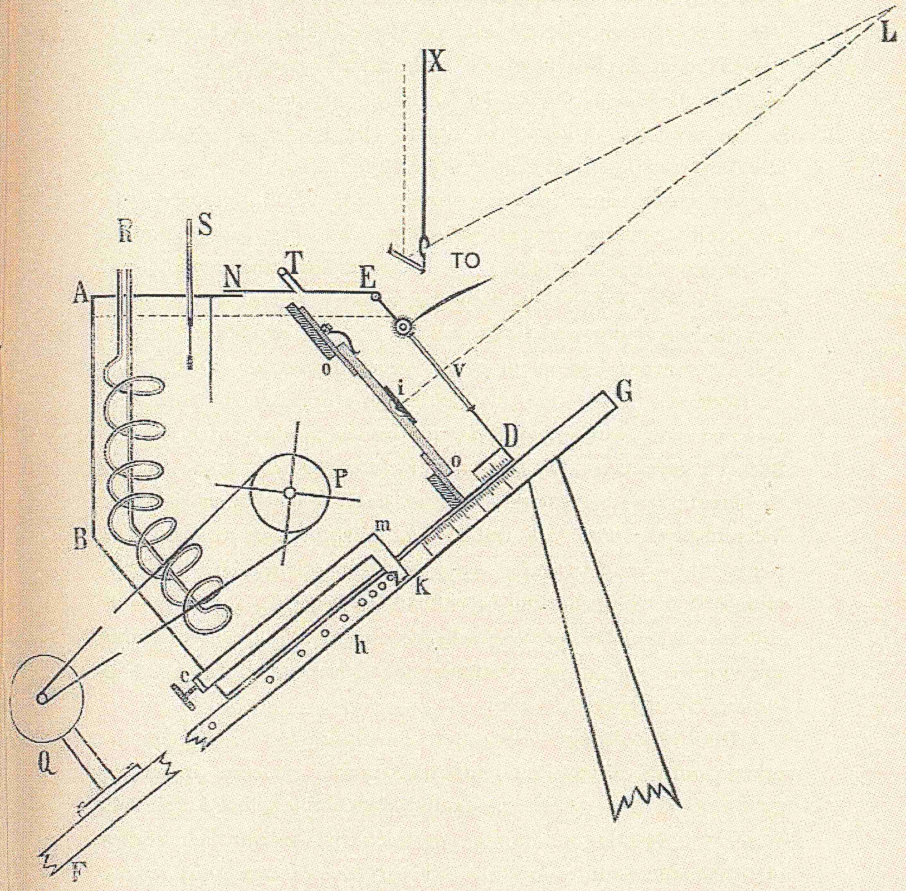
to be able to vary its intensity in a calculable manner.

I will describe here the setup and arrangement of the apparatus when using electric light; with appropriate modifications to the setup, it can also be used for sunlight.

Before I discuss the details, I will note for orientation that the principle used consists in spreading the bacterial culture in the thinnest possible layer, e.g., as a hanging drop, on a thin quartz plate. This quartz plate is applied as the ceiling of a "humid chamber." This chamber (hereinafter referred to as the "culture apparatus") is placed in a box filled with water. This water is kept in constant flow and at a constant temperature by a wheel. The light is admitted through a quartz window in the side of the box

The light source. The electric arc lamp (see L in the figure) is suspended in the manner customary at the Finsen Light Institute, so that it can be moved up and down, as well as in all directions, and fixed in any position using screws. The carbon thickness is chosen empirically so that the arc always maintains the same position in space as far as possible. Since this is difficult to achieve with absolute accuracy, as one carbon usually becomes somewhat shorter than the other after a longer period of time, thereby shifting the arc somewhat, I have always conducted the experiments with freshly inserted carbons of a specific length. During the course of a normal series of experiments, 1 to 2 hours, the arc does not noticeably change its position; however, for longer experiments, it may be necessary to lower or raise the lamp slightly. To adjust the position of the arc

To check this precisely, I attached a small projection device (Z) to the screen surrounding the lamp (X);



Photocteinometer.

This consists of a biconvex lens and a plane mirror, through which an enlarged image of the carbon tips and the arc is projected onto a screen on the wall of the laboratory

drawn scale. Every change in the position of the arc is immediately apparent in this way and can be corrected immediately. It is also of the utmost importance to continuously observe the arc in this way in other respects. Even if one places one carbon as precisely as possible in line with the axis of the other, it very easily happens that the "crater" of the positive carbon burns crookedly, causing the light to be thrown more strongly to one side. For experiments that are carried out immediately one after the other and are only to be compared with each other, this circumstance does not play a major role, since a crater that is not too crooked will retain the same direction and shape for hours; but in order to be able to compare experiments that are carried out after longer intervals, one must avoid crookedness in the crater formation, which is made much easier by monitoring the carbon tips from the beginning using the aforementioned projection device In the series of experiments described below, I always used a current of 35 amperes with a voltage of 50 volts. Regarding the accuracy of the regulation, I refer to the experimental protocol reproduced below. The positive carbon (the upper one) in the lamp used had a diameter of 24 mm, the negative one 15 mm.

The setup. In front of and below the lamp is a rectangular board (FG), which is firmly positioned at a certain angle to the axis of the carbons. The light emanating from the arc is, as is well known, distributed extremely unevenly in space; the largest amount radiates obliquely downwards in a belt between 450 and 550 degrees with the axis of the carbons; above and below this belt, the light intensity falls very rapidly. Which angle is chosen is, in itself, quite unimportant for comparative experiments; only

one must always choose exactly the same one I have provisionally chosen 45° for external reasons, but I do not recommend this angle as the most suitable, because a slight lack of precision in the setup becomes more significant than, for example, with 50°, because the former angle is too close to the point where the luminous intensity decreases sharply with increasing angle. If a different angle is chosen, one must consider the possibility that not only the luminous intensity but also the relative proportions of the various colored rays can change with the angle of radiation (incidentally, I later attached the board to the lamp suspension so that it can be mounted in all radial positions, with the arc as the center). Not only must the board be at the angle in question, but the extension of its surface must also intersect the axis of the lower carbon so deeply below the arc (at the size ratios given below, approximately 6.5 cm below the tip of the lower carbon) that the rays that hit the center of the quartz window run parallel to the surface of the board.

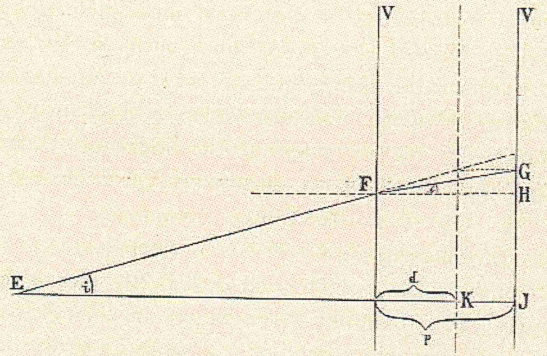
The sheet metal box (ABCDE), in which the culture apparatus is to be mounted, is attached to the board by means of the brass bracket (cmk); at k, it is provided with a notch, with which it is attached to one of the pins (2). These are placed on the sides of the board at such intervals that the luminous intensity at the point inside the box where the cultures are located takes on the values 10/10, 9/10, 8/10, etc., depending on the pin used. The calculation of these distances is, of course, done using the law of decay of luminous intensity inversely proportional to the square of the distance. If we set the unit as the exposure L that occurs at an arbitrary distance a from the light source, we have

the distance, A, where the illumination is of the desired magnitude /, in the formula: A = a V

If, for example, as I did below, one takes the illumination at a distance of 280 mm as the unit, one has

Illumination 1.0 at a distance of 280 mm

- $O_{.9}$ - 295 - -
- $O_{.8}$ - 313 - -
- $O_{.7}$ - 335 - -
- $O_{.6}$ - 361 - -
- $O_{.5}$ - 396 - -



However, it must also be taken into account that the rays come somewhat closer together because they are refracted in the water layer in front of the culture, whereby the illumination becomes somewhat stronger than the distance would suggest. If VV represents the boundaries of the water layer, its thickness, and E the light source, the ray EF will take the direction FG in the water; the light filling the angle ż will thus concentrate on the surface space GF, which space it would have occupied without the water layer at

distances EK. If i is the angle of incidence, b the angle of refraction, and n the refraction ratio of the liquid, then one has

p.tgb P = = d. tgi tgi tob' if .

$\frac{d}{GH}$ = the angle

of incidence is small (see below), one has tgi sin i tg b

$$\sin b = \frac{}{n}$$

To obtain a quantity of light corresponding to distance A without a water layer, one must take the

$$\text{distance } A+p+d=A+p(1) \div \frac{1}{n}$$

with a water layer. If one calculates the refractive ratio of the water - 3/4, the distance must therefore be equal

to $A+P\ ^{4}$ —

The finer adjustment of the box is done by means of two screws (at C), partly so that the distance between the light source and the culture is the desired one, and partly so that the front surface of the box (ED) is exactly perpendicular to the direction of the light rays used (Li). The result can be seen by means of special marks on the sides of the board and on the box (at D). These marks were originally marked by attaching a small piece of mirror glass to the middle of the front surface of the box and then adjusting it so that the reflection of the arc is reflected back into the box itself, which only occurs when Li ≤ ED

The front surface of the box has a circular window (2) made of a 1.5 mm thick, plane-parallel ground quartz fins Medical

plate; this plate is cut perpendicular to the optical axis of the crystal. The diameter of the window is 43 mm, and its center is 5 cm above the bottom of the box. With the setup discussed above, a straight line from the arc will run through the center of the window, parallel to the surface of the board. This is very important if one wants to compare the effects of different light intensities by moving the box along the board; for in the opposite case, for example, if one had placed the box further down on the board, one would not only have changed its distance from the light, but it would immediately receive rays emanating at a different angle to the axis of the carbons, thereby introducing entirely new moments (cf. pp. 14-15). Since the arc light does not emanate from one point, but from the crater of the upper carbon, the arc, and the tip of the lower carbon, one must define more precisely what is meant by the "distance of the light," and this is particularly important when the distance is not large. It is very difficult, given our current state of knowledge, to say which measuring point is the best; the first experiments reproduced below (series 1-36) were all carried out at the same distance; I was therefore able to use the most convenient measuring point in practical terms without hesitation, namely the point closest to the culture on the narrow white ring that forms on the positive carbon a few millimeters above the rim of the crater; it also corresponds fairly well to the nearest part of the strongest light, since this ring forms on the boundary between the white- and red-hot parts of the carbon. Whether I will retain this measuring point in the future will depend on whether it can be discovered from which points on the carbon or the

arc emits the greatest amount of bacteria-killing rays. As long as one always maintains the same distance, it is only important that one measures from the same point in all experiments. This distance is checked before each series of experiments, and for this purpose I use a sheet metal plate on which each of the determining points is marked once and for all. If fresh coals are used, the lamp must first burn for about a quarter of an hour for the ring discussed to form

The entire sheet metal box is filled with the liquid through which the light is to be filtered, usually with freshly boiled distilled water. To keep the temperature constant, warm or cold water is passed through the spirally wound lead tubes (R); the water leaves the box again through the other end of the tube without coming into direct contact with the liquid in the box. In the center of the box, a paddle wheel (P) is mounted on a through shaft, which is kept in vigorous rotation by a small electric motor (2). To ensure that the water can be stirred as thoroughly as possible, the paddles are mounted obliquely on the axle, so that in addition to the rotating movement of the water, a powerful current perpendicular to it is obtained. The speed of the motor is regulated by switchable incandescent lamps

— The temperature of the water is read on the thermometer S; its container is protected from direct rays by a small screen. At T there is an opening for a thermometer with a blackened container, which is to be placed directly next to the culture, exposed to light. The entire inner side of the box, as well as the lead tubes, are matte black to protect the culture from reflected light.

At a certain distance behind the quartz window (at 00) is a metal backdrop into which a brass frame, supporting the culture apparatus by means of springs, can be inserted. In the following experiments, I used a "humid chamber" with a hanging drop as the culture apparatus; the cover plate is made of plane-parallel ground quartz, cut out perpendicular to the optical axis. The thickness of this covering quartz is 0.9 mm; after the culture drop is attached to its underside, the covering quartz is glued to the object glass; this has a spherical segment-shaped cutout, 1 mm deep, 14 mm in diameter, into which the curved surface of the culture drop thus projects freely. The distance between the front surface of the covering quartz and the back surface of the quartz window, or in other words: the thickness of the light-filtering liquid layer, can be varied as desired; In the experiments described below, I always used a distance of 25 mm. (In later versions of the apparatus, I varied the thickness of the water layer by securing the quartz window in a tube that could be adjusted by means of a thread.)

In the figure, at u, you can see a small lid which, moved by means of a small stem, can expose the quartz window to light and cover it again. NE is the lid of the box; it is attached in — such a way that, when open, it shields against the light, so that the culture apparatus can be removed and inserted without being exposed to light; of course, they must also be protected from light during transport to and from the box.

The advantages of this apparatus.

1. The optical conditions are simple If the lamp, as discussed, is maintained at a constant current and voltage, with the same type of carbon, without shifting the arc or the direction of the crater, the intensity of the light striking the front surface of the quartz window depends on the distance, the angle of radiation, and the angle of incidence; these three quantities are all precisely known. The refracting surfaces are approximately (see below) perpendicular to the direction of the rays used. The reflection and refraction are as simple and straightforward as possible, since between the light and the culture there is only a plane-parallel layer of distilled water, of known thickness, sandwiched between two plane-parallel polished quartz plates. The surface of the culture is also plane and perpendicular to the rays, being formed by the side of the drop—whether made of a solid or liquid medium—which touches the covering quartz. Because the back convex surface of the drop is concave to the light, the light has unhindered access to every single part of the drop. Only if the drop were curved to form more than a hemisphere would the reflection cause some parts of the interior of the drop to be in the dark; but it is very easy to make the drop flat, and if it is supported with a platinum loop of the appropriate size, it will naturally assume a suitable shape. The bouillon drop I used was 1.5 to 2 mm wide from side to side, and 0.05 to 0.15 mm deep from front to back.

Under these simple conditions, one can determine, both by calculation and by direct experiment, what percentage of the light used reaches the culture drop. I have not yet undertaken an exact determination of these conditions, simply because I have not had any use for them so far. I have only calculated a few limiting values to be on the safe side: The ray that deviates most from the incidence slot, which can be imagined under the given conditions, is obtained if we place two slides next to each other in the apparatus and if we have placed four drops on each of the two covering quartz crystals, and if the cultures are illuminated at the shortest distance from the light; I have chosen 280 mm as the shortest distance. The outermost point of the most practical drop then comes at most 18 mm to the side of the center line (i.e., the line connecting the center of the light ray will then be source and the center of the quartz window). The most deviating the one that, for example, B. from a point on the extreme right of the upper coal towards the extreme point of the leftmost culture drop. But even such an extreme ray deviates, where it hits the quartz window, only 5° 52' from the normal to the incidence. In addition, this ray, like its nearest neighbors, has only an extremely low luminous intensity because their angle of radiation is almost 90°. But even if one were to assume that some of the rays have an angle of incidence of approximately 6°, this plays only a negligible role in practice. According to Stolze (quoted by Eder), the light loss due to reflection from a flat glass plate at an angle of incidence of 0° is < 0.66%, at 5° it is 1.5%, and at 15° it is 3.4%. Thus, none of the rays used would have more than approximately 1.5%.

lose, the majority of them even less. I have not been able to find in the literature how the reflection from a quartz plate behaves, but I can casually assume that it does not behave significantly differently than from glass. With regard to visible rays, Mr. Absalon Larsen found through direct experiments that at the angle of incidence o, only about 0.35% is reflected from the quartz surface Reflection at the quartz-water interface (where the discussed "unfavorable" ray strikes at 3° 48'), water-quartz (4° 24'), and quartz-nutrient medium (3° 48') can certainly be neglected in practice because the difference between the refractive indices of these substances is so small. Within the nutrient medium itself, the most unfavorable ray will deviate only 4° 20' from the normal. During these various refractions (where the refractive indices for quartz, water, and nutrient medium are set at 1.54, 1.33, and 1.35), the most deviated ray will be 0.74 mm closer to the center line. I have already taken into account the resulting concentration of light, which, as can easily be demonstrated, occurs over the entire illuminated surface, when calculating the distance (p. 17).

While the luminous intensity suffers a slight attenuation due to reflection, it is, on the other hand, slightly amplified by a reflection from the rear surface of the nutrient drop, whereby a portion of the light passes through the drop twice. This amount of light will not be large, and in similar experiments it will be approximately the same each time.

The loss due to absorption is also very small. One usually wishes to have a certain kind of absorption, namely of a portion of the ultra-red heat-

rays, which are held back particularly by the water layer, and partly also by quartz. For the remaining rays, including ultraviolet rays, quartz and water are the two most permeable materials that can be considered; as far as certain invisible rays are concerned, this is already clear from my experiments with quartz discussed on page 6. For the visible spectral region, H. Rubens and E. Ashkinas state that quartz possesses "almost perfect" permeability, so that the absorption loss cannot be measured at all.

2. The luminous intensity can be graduated with precision. Since it is not possible to vary the intensity of the light source according to a sufficiently precise scale, and since the various methods of measuring light have all been partly cumbersome and inaccurate, and partly completely ineffective, when it comes to determining ultraviolet rays, the most accurate method, as far as I can see, for obtaining various specific light intensities is to use the lawful decrease in luminous intensity inversely proportional to the square of the distance.

Conversely, this device will contain a measuring device to determine the bactericidal radiation content of a light source (e.g., a light-collecting device). Such a measuring device is all the more necessary because we currently have little knowledge of which part of the ultraviolet rays has the most bactericidal effect, much less have we been able to measure their quantity. —

3. The light absorption of the culture medium is limited as much as possible by using it in very thin layers (0.05-0.15 mm) for subsequent tests. A preliminary determination

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according to what Mr ABSALON LARSEN has done for me, absorbs both agar and broth in layers of a few millimeters about half of the silver chloride rays, and one can certainly expect that the absorb bacteria-killing rays at least as strongly The fact that absorption, on the other hand, is not a practical I conclude that the thickness of the drop plays a rôle in the very thin layers mentioned above: although in most of my experiments I intentionally placed a somewhat thicker drop next to a very thin one, I was unable to demonstrate a consistent difference in the results. At the limiting values, where the bacteria often grew in one of the (usually four) drops deposited on the same covering quartz, while the remaining drops remained sterile, the bacteria grew just as often in one of the thin drops as in one of the thick drops. Of course, the thickness of the drop cannot be entirely without influence; but I can say that it plays no role as long as the gradations of the illumination times are not made smaller than in the subsequent experiments. I hope to be able to demonstrate later how the exact limit for the largest permissible drop thickness can be determined by the apparatus itself.

This, incidentally, is not the only advantage of the hanging drop. Apart from the fact that, as discussed above, the side of the culture facing the light is made completely flat, it also ensures that oxygen has very easy access to the entire culture, as the hollowed space of the slide is many times larger than the culture drop, a circumstance to which one must attach all the greater importance, as several researchers have stated that they have obtained different results depending on whether the exposed test tubes, etc., were more or less highly charged with

filled with the nutrient fluid. A great advantage of the drops is the small space they take up; one can easily place, for example, four drops on the same covering quartz, and two such drops (each with four drops) can fit next to each other in the apparatus, or if each slide carries two hollow — ground glass sections, a total of 16 drops without any ray receiving a less favorable — direction than calculated above. If, on the other hand, larger culture vessels were used, a corresponding number of these would take up so much space if they were to be illuminated simultaneously that a possible oblique position of the crater would cause a very significant difference in the amount of light reaching each individual drop. Finally, the small size of the drop allows one to conveniently investigate the effect of a narrowly defined zone of a given light field, e.g., a specific region of a spectrum

The fact that all exposed bacteria are accessible to direct microscopic examination may also be important.

The possibility that drops placed on the same covering quartz infect each other cannot be completely ruled out, although a glance at the tables below will show that this, if it occurs at all, is certainly very rare. I have not yet seen a case where I suspected it had occurred. But to avoid such an objection, I have always placed only drops taken from the same culture next to each other. If one sees outgrowth in more than one drop, a skeptic could perhaps claim in an individual case that one drop had infected the others; but in one of the drops, he must admit, the bacteria have not all been killed. And no objection can be raised against the drops

that remain sterile after exposure to light (see, incidentally, "The Explanation of the Experiments," p. 78).

Before me, Pansini and, to some extent, Kruse used the drop method, both in experiments with sunlight and using cover glasses. I am only familiar with Pansini's experiments from a brief report; he is said to have found that anthrax bacilli are killed in 70 minutes. Kruse achieved similar results (summer sun, Naples); however, he only applied the method in a few experiments, which, incidentally, he describes so sketchily that I do not feel obliged to go into them in more detail

4. The temperature conditions are taken into account. Above all, it is important to ensure that the temperature of the nutrient medium does not rise so high that the death of the microbes could be due to the heat. The culture is cooled by being surrounded by water, which is kept in lively flowing motion by the motor. Since the covering quartz is thin and the quartz is also a relatively good heat conductor, and since the drop is very thin, the conditions are particularly favorable for keeping the culture at the same temperature as the surrounding water. To see to what extent this reasoning corresponds to the actual conditions, I conducted the following experiments:

The simplest, and actually convincing, way is to illuminate your own finger at the location of the culture. Even at the shortest distance from the light (28 cm), and even if the finger was blackened, if the motor is running at the appropriate speed, you feel no warmth in your finger other than that resulting from the temperature of the water

speaking, while outside the box, at the same distance, one feels vivid pain after less than a minute. For greater certainty, in very numerous experiments, carried out at very different water temperatures, I placed a thermometer with a sooted container through the opening T (see the figure) directly next to the culture. The temperature difference between this thermometer and the shaded one (S) never reached 14. Finally, the following experiments seem completely convincing to me: On the back of the covering quartz, directly next to or between the culture drops, I placed small cubes made of substances with different melting points (butter, Vaseline, and especially various paraffins with melting points of 41.5°, 45°, 50°). These can be illuminated for as long as desired, at a distance of 28 cm, without them melting, as long as the water temperature is kept below the melting point of the substance in question; If the temperature of the water is allowed to rise, the cubes do not melt until the shaded thermometer shows temperatures that are at most 1/20 below the actual melting point. Even when these substances are kneaded with soot, this ratio remains almost unchanged. In all experiments below 36.5°C, the covering quartz is adhered to the microscope slide by means of yellow Vaseline (mp 36.5°C); as soon as the water temperature exceeds 36.5°C, it melts immediately and the covering quartz sinks to the bottom; at all temperatures up to 36.5°C, the Vaseline shows no sign of melting, even after hours of illumination.

Of course, the effect of heat rays is not entirely excluded if the thickness of the water layer is only 25 mm and the distance 28 cm. But it is not the intention, at least for the time being, to completely exclude them.

conclude that it is probably most natural to begin the investigations with a light that contains all the elements, including the heat rays; only, it is necessary, by means of water and quartz, to eliminate such a large portion of the heat rays that the culture drop can be maintained at the temperature chosen for the individual experiment. In other words, it is not the heat rays as such that must be avoided, but rather an excessively high temperature of the culture fluid, and the tests discussed above prove that we have prevented such a situation.

For practical reasons, too, the effect of the heat rays must be studied within these limits; for should it turn out that they have a bactericidal effect, they could very well be used therapeutically because, as discussed, the skin nerves have no objection to illumination under these conditions

I do not limit myself to keeping this temperature so low that it cannot harm the bacteria; I also keep it constant in each series of experiments because it is quite probable a priori that the light effect will not be the same at all temperatures, which is also confirmed by my experiments (see p. 93).

5. Stirring by means of a paddle wheel achieves three things: First, it keeps the temperature constant everywhere in the box. Second, the experiments with paraffin cubes discussed above have shown that the temperature in the humid chamber cannot be kept the same as the temperature of the surrounding water if stirrers are not used. Third, this prevents dust particles and similar unavoidable impurities from settling on the

to fix covering quartz. A speck barely visible to the naked eye would otherwise suffice to provide a shadow for a few bacteria, which could later populate the entire drop, at least when using a liquid nutrient medium.

Precaution when using the apparatus.

The quartz plates must be completely clean. An almost invisible film of dirt is sufficient, as has been shown on many occasions (e.g., our experience with therapeutic light-collecting apparatus), to reduce the effective amount of light to an unexpected degree. The quartz window must therefore be carefully polished on both sides immediately before the start of the experiments, and during the experiments, one must continually pay attention to it, removing every speck of dust and the like using small, specially designed instruments (a fine brush for the outer side, a glove-leather buff for the inner side of the window). For experiments lasting only a few seconds, these manipulations must be performed before the culture is placed in the box; for longer experiments, it makes no difference if a speck of dust is brushed away with a quick movement. The same amount of effort must be applied to the covering quartz. Before the experiment, these are washed in spirit, carefully dried, and every visible speck of dust is removed with a brush. Afterwards, each one is individually wrapped in smooth paper and, like the corresponding microscope slides, sterilized at 140°C. After the culture drops have been deposited on the underside of the covering quartz using a platinum loop of a certain size,

are set, it is adhered to the slide using sterile petroleum jelly; if temperatures above 35°C are to be used, a layer of Unguentum cerae (Ph. dan.), which only melts at 58°C, is also placed around the edge of the covering quartz. Care must be taken to ensure that no trace of petroleum jelly gets on the front surface of the covering quartz, because even the thinnest layer can block the majority of the ultraviolet rays, as petroleum jelly is very strongly fluorescent

Another significant source of error can be the water in the box. You must use freshly boiled, distilled water; otherwise, it is difficult to prevent the formation of small air bubbles, which, among other things, settle on the covering quartz. A minimal air bubble is enough to protect a large number of bacteria from the light, and before I realized the significance of these bubbles, it was impossible for me to obtain consistent results. If you use a liquid other than distilled water, you must not forget that the absorption conditions are different. Even ordinary tap water absorbs the majority of ultraviolet rays. You must also avoid electrolytic effects as much as possible through careful varnishing so that no metal salts are formed

2) Experimental Protocol I.

Variations in the resistance of B. prodigiosus according to the age of the culture and the temperature of the nutrient medium.

In the following, I do not limit myself to reporting my results, but I reproduce my experimental protocol verbatim, even the unsuccessful experiments, because the development of the experimental method is not without a certain interest.

The following conditions are common to all experiments in this first protocol (series 1-36):

The lamp (shunt lamp from Siemens & Halske). Positive carbon 24 mm diameter, negative carbon 15 mm diameter, current 35 amperes. The rheostat available in experimental series 1-33 functioned somewhat poorly, so that the current could not be maintained exactly at 35; it was kept between 35 and 3534 A, on average at 35/3 If 35 A is noted in the experimental protocol, this margin is meant. If a larger fluctuation occurred now and then, it will always be explicitly noted. From series 34 onwards, a rheostat was used, which I had manufactured so that arc lamps could be switched on one after the other or several at the same time, in parallel with the main resistance, whereby the current intensity could easily be maintained so constant that the oscillations could hardly be seen on an ordinary ammeter. The voltage was kept as far as possible between 50 and 52 volts and is noted for each individual experiment. How great an influence on the amount of bactericidal rays

Variations in current and voltage within these limits must be left to later experiments. It is usually stated that the intensity of visible light increases somewhat more than proportionally to the current. According to the experiments of Absalon Larsen (see later), one can expect that a variation in current of 30 to 31 amperes corresponds approximately to a 5% increase in luminous intensity in the region of lines K and H. I myself obtained similar results through experiments with silver chloride paper. A large proportion of the small irregularities within the individual series of experiments could be plausibly explained by this source of error. But for now, it must be noted that, according to other experiments carried out at the Light Institute, the intensity of the bactericidal rays does not appear to increase proportionally to the rays acting on silver chloride.

The light filter always consisted of distilled water 25 mm thick (as well as the two quartz plates).

The test subject was always B. prodigiosus in pure culture. At appropriate intervals, I assured myself that the cultures were still pure. Both the cultures and the sterile nutrient medium were always kept in the dark; when they were taken out, I always avoided direct exposure to sunlight or arc light. After the illumination was complete, the culture apparatus was placed in the incubator, the temperature of which was 22°C in row 1-30, and always 25°C in the later rows, because it was impossible to maintain a constant temperature of 20°C in the hot summer months.

In all doubtful cases, the diagnosis of "growth" or "death" was confirmed by inoculation into fresh nutrient medium.

The nutrient medium was always the lightest possible, slightly alkaline veal broth, prepared according to the general procedure in Salomon's bacteriological technique. When salts or similar impurities began to separate, a new portion was prepared. The bacteria were cultivated in test cylinders of constant size and shape, each containing exactly 2 cm^3 of broth.

The distance of the light source from the front surface of the culture was always 280 mm. Since part of this distance is taken up by a 25 mm thick layer of water + 2.5 mm quartz, the light intensity, according to what was developed on page 17, would have corresponded to a distance of 273 mm without the use of such light-refracting media.

The time was measured using a chronograph that allowed readings of 1 second

Explanation of the tables: A Ampere, V = Volt, sec. the time the culture drop in question was exposed to light, given in seconds. O means that the culture was not illuminated at all, i.e., control experiment; the temperature indication in such a case means that the culture was exposed to the respective temperature in the box without illumination. Or 1 T., 2 T. indicates the number of hours, or days, that have passed individual 1 hour, or 2 hours, since illumination, at the time when the culture drop is examined. + means that the bacteria have grown diffusely throughout the drop, that the drop remains clear, i.e., without visible growth. s means that the bacteria have grown "scattered," o: they have grown only in individual, circumscribed parts of the drop (I will return to the explanation for this later). In rows 1-6, I did not distinguish between and s, and I am

I am also not sure that I defined "s" in the first 12 rows in the same way as later. If there are several +, or, or s in a column, this means that a corresponding number of separate drops were placed on the relevant covering quartz.

— I have used italics throughout the experimental protocol for those comments that I later added to the original text written during the experiments.

Rows 1-4.

($^{26}/_{1}$.—$^{3}/_{2}$. 99.)

No.	Tp.	A	v.	Sek.	1 T.	2 T.	4T.	5T.
1	30°	34—35	50—52	300	—	+	+	+
2	„	35	51—53	420	—	+	+	+
3	„	„	51—53	660	—	—	?	+
4	„	„	52—54	900	—	?	+	+
5	„	—	—	0	+	+	+	+
1	30°	35	49—51	900	—	—	—	—
2	„	„	50—52	1200	?	+	+	+
3	„	„	50—52	1500	—	—	—	—
4	„	„	52—53	600	—	—	—	—
1	30°	34—36	51—55	3000	—	+	+	+
2	„	35	52—54	3300	—	—	—	—
1	30°	35	51—55	1800	—	—	—	—
2	„	„	„	2100	—	—	—	—

These preliminary experiments seem incomprehensible. Even 3000 seconds doesn't always seem sufficient. However, the 3000-second illuminated culture itself provides a clue to the right path; it turned out that a very thin layer of petrolatum was present on the coverslip. Perhaps the small air bubbles forming on the cover quartz also played a role.

Row 5. (8/2.99.)

All air bubbles are removed as soon as they form.

No.	Tp.	A	v.	Sek.	1 T.	2T.	3T.	4T.
1	30°	34—36	49—51	480	—	—	—	—
2	„	35	50—52	600	—	+	+	+
3	„	„	52	660	—	—	—	—
4	„	„	51—52	720	—	—	—	—
5	„	„	52—54	900	—	—	—	—
6	„	„	49—53	1200	—	—	—	—
7	„	„	—	0	+	+	+	+
8	„	„	—	0	+	+	+	+
9	„	„	—	0	+	+	+	+

No. 2 grew in a manner we later call "dispersed." We see that after removing the air bubbles, the bacteria are killed in a shorter time than in row 1.

Row 6. (11/2.99.)

No.	Tp.	A	v.	Sek.	1 T.	2 T.	3 T.	4 T.	5 T.
1	30°	—	—	0	+	+	+	+	+
2	„	—	—	0	+	+	+	+	+
3	„	35	50—52	240	—	+	+	+	+
4	„	„	„	300	—	—	—	—	—
5	„	„	„	360	—	+	+	+	+
6	„	„	50—51	420	—	+	+	+	+
7	„	„	50—52	480	—	—	—	—	—

To completely avoid the formation of air bubbles, distilled water is used here (as in all subsequent experiments) immediately before the experiment. Continued cultivation reveals that the fully grown colonies are indeed Prodigiosus. Some are now killed in just 300 seconds or 5 minutes.

Series 7. ($15/_2$. 99.)

The window is now (as always later) carefully cleaned immediately before the experiment with hydrochloric acid, spirit, and water and then polished.

No.	Tr.	A.	V.	Sec.	1 T.	2 T.	3 T.
1	30°	—	—	0	+	+	+
2	"	35.5	53—54	60	s	+	+
3	"	35	52—54	120	s	+	+
4	"	34—36	53—54	180	?	+	+
5	"	35	52—54	240	—	s	+
6	"	34—36	53—54	300	—	—	—
7	"	35	53—54	360	—	s	+
8	"	35	51—54	420	—	s	+
9	"	—	—	0	+	+	+

No. 6 The lamp regulated poorly.
No. 6 was sterile even after inoculation.

Row 8. (18/2.99)

No.	Tp.	A.	V.	Sec	1T.	2 T.	3 T.	4 T.	10 T.
	30°		—	0	+	+			
2	"	—	—	0	+	+			
3	"	35	50	60	s	s			
4	"	"	50	120	?	s			
5	"	"	50—53	150	—	s			
6	"	"	51—52	180	—	s	+	+	+
7	"	?	?	?	—	s	+	+	
8	"	35	49—51	240	—	—	—	—	—
9	"	"	49—51	270	—	s			
10	"	"	48—52	300	?	s	+	+	

Series 9. (1/3. 99.)

No.	Tr.	A.	V.	Sec.	1 T.	2 T.	3 T.	5 T.
1	30°	35	50—51	60	?	s	+	+
2	"	33—36	"	120	—	—	—	—
3	"	35	"	180	s	s	s	s
4	"	"	50—53	240	—	s	+	+
5	"	"	50—52	300	s	s	s	s
6	"	"	"	120	—	s	s	s
7	"	"	49—52	180	—	s	s	s
8	"	"	50—52	240	—	s	s	s
9	"	"	50—51	120	—	s	s	s
10	"	"	"	180	s	s	s	+
11	"	"	49.5-52	240	—	—	+	+

Nos. 3, 5 and 11. By continued inoculation it is determined that it is truly Prodigiosus.

Since the drops have so far been taken from more or less old, strongly red cultures, one considers the possibility that the inconsistent results could be dependent on the pigment crumbling. Therefore, experiments are now being carried out with very young cultures; but because the age of the culture is not yet considered of great importance, experiments with different temperatures are being carried out at the same time. The exact age of the culture is also not noted.

Series 10. (9/3/99)

No.	Tr.	A.	V.	Sec.	1 T.	2 T.	3 T.	4 T.	6 T.
1	10^0	—	—	0	+	+	+		
2	„	—	—	0	+	+	+		
3	„	—	—	0	+	+	+		
4	„	—	—	0	+	+	+		
5	„	34·5-35·5	49—53	300	—	—	—	—	—
6	„	35	49—52	360	—	—	—	—	—
7	„	„	48—52	420	—	—	—	—	
8	„	„	49—52	480	—	—	—	—	
9	„	„	47—51	540	—	—	—	—	
10	„	„	51—55	600	—	—	—		
11	„	„	49—51	720	—	—	—		
12	„	35—36	48—52	360	—	—	—		

Nos. 5 and 6 were found to be sterile by inoculation.
The drops were deposited from a very young culture.
In this series (as in all subsequent ones), the moist chambers are blindly removed from the row of finished preparations as a control, so that the order in which the drops were deposited has no influence; only then are they numbered and illuminated

Series 11. (17/3/99)

No. Tr.		A.	V.	Sec.	1 T.	2 T.	3 T.	4 T.
1	10^0	—	—	0	+	+	+	+
2	„	34·5-35·5	50—51	60	—	?	+	+
3	„	35—36	49—53	120	—	—	—	—
4	„	35	49—52	180	—	—	—	—
5	„	"08	(47)—54	240	—	—	—	—
6	„	35—36	47—54	300	—	—	—	—
7	„	35	50—56	360	—	—	—	—

The lamp regulates poorly.

From Nos. 3-7, inoculation with broth is carried out in the same glass; the same remained sterile

With rows 10 and 11, we have a completely new picture: consistent results and sterilization in less than 120 seconds. To see whether the reason for this could be that the temperature was 10, whereas in the earlier experiments it was 30, the following series of experiments is carried out:

Row 12. (21/3. 99.)

No.	Tp.	A	v.	Sek.	1 T.	2 T.	3T.
1	—	—	—	0	+	+	+
2	—	—	—	0	+	+	+
3	20°	35	51—53	180	—	—	—
4	„	„	53—55	120	—	—	—
5	10°	35	50—53	180	—	—	—
6	„	„	50—52	120	—	—	—
7	„	„	50—52	90	—	—	—
8	„	„	50—51	60	—	—	—
9	40°	35	50—52	180	—	—	—
10	„	„	50—52	120	„	„	„
11	30°	35	49—52	180	—	—	—
12	„	„	49—52	120	—	—	—

No. 10 failed because the covering quartz slipped down because the petroleum jelly melted; it got stuck in No. 9, although the Vaseline melted immediately here too.

Nos. 7 and 8 were inoculated in broth; this remained sterile.

According to this, it is hardly the temperature differences that were decisive in rows 10 and 11. Rather, one had to try to determine the influence of the age of the culture.

Row 13. (28/3.99.)

No.	Tp.	A	v.	Sek.	1 T.	2 T.	3 T.	4T.	
1	—	—	—	0	+	+	+	+	
2	—	—	—	0	+	+	+	+	Old
3	20°	35	51	60	—	+	+	+	approx. 6
4	„	„	50—51	120	—	—	—	—	Hours
	„	„	50—52	180	—	—	—	—	
6	—	—	—	0	+	+	+	+	
7	20°	35	49—51	60	—	s	s	s	Old
8	„	„	50—53	120	—	s	s	s	approx. 30
9	„	„	49—53	180	—	—	—	—	Hours
10	„	„	51—52	60	?	+	+	+	Old
11	„	„	50—53	180	?	+	+	+	approx. 54
12	„	„	49—53	360	—	—	—	—	Hours

From No. 12 is vaccinated in broth; this remains sterile.

No. 1-5: The drops were from a 6-hour-old, still clear broth culture.

No. 6-9: Ditto from a 30-hour-old, unclear bouillon,

No. 10-12: Ditto from a 54 hour very unclear bouillon culture.

So age seems to be important. The 6 hour old culture was killed between 60 and 120 seconds, while the 54 hour old took between 180 and 360 seconds,

Series 14. (24.99.)

No.	Tr.	A.	V.	Sec.	IT.	2 T.	3 T.	4 T.	
1	—	—	—	0	?	+	+	+	
2	—	—	—	0	?	+	+	+	
3	30°	35	50—52	20	—	—	—	—	
4	"	"	52	40	—	—	—	—	
5	"	"	51	60	—	—	—	—	Age approx. 6 hours
6	"	"	51—52	80	—	—	—	—	
7	"	"	51—52	100	—	—	—	—	
8	"	"	51—52	120	—	—	—	—	
9	"	"	51—53	140	—	—	—	—	
10	30°	35	51—52	100	s	+	+	+	
11	"	"	50—53	140	—	—	—	—	
12	"	"	50—53	180	—	s	+	+	
13	"	"	49—51	220	—	—	s	+	Age approx. 56 hours
14	"	"	50—53	260	—	—	—	—	
15	"	"	49—52	300	—	—	—	—	
16	"	"	48—53	340	—	—	—	—	

Nos. 1-9 separated from approximately 6-hour-old, still clear broth culture.

Nos. 10-16 from approximately 56-hour-old, very unclear broth culture

The influence of age again seems unmistakable; closer inspection, however, shows that this series is only slightly convincing in this respect, because the 6-hour-old culture was (for an unknown reason) already very weak before illumination, since the control drops showed hardly any visible growth even after 24 hours, and because the culture was sterile after just 20 seconds of illumination, which is quite abnormal (cf., for example, the following series).

Series 15. (4.99.)

No.	Tp.	A.	V	Sec.	IT.	2 T.	3 T.	4 T.
1	—	—	—	0	+	+	+	+
2	—	—	—	0	+	+	+	+
3	—	—	—	0	+	+	+	+
4	30°	35	50	5	+	+	+	+
5	29°	"	50	10	—	+	+	+
6	"	"	51	15	—	s	+	+
7	"	"	51	20	—	+	+	+
8	"	"	51—52	40	—	s	+	+
9	"	"	51—52	60	—	+	+	+
10	20°	35	50	2	+	+	+	+
11	"	"	50	5	+	+	+	+
12	"	"	51	10	+	+	+	+
13	"	"	50	15	+	+	+	+
14	"	"	50	20	+	+	+	+
15	"	"	50—51	40	—	+	+	+
16	"	"	51	60	—	—	—	—

Nos. 1-16 from a 6-hour-old broth culture.

In this series, as in most of the previous series, the duration of illumination was unfortunate, so that the killing limit is not clearly visible. From the next series of experiments onwards, based on the experiences gained in series 1-15, I have been more fortunate in this respect

Series 16. (15/4.99.)

No.	Tr.	A.	V.	Sec.	1 T.	2 T.	3 T.	5 T.	6 T.
1	30°	34	50	5	—	?	+	+	+
2	„	35	50	10	—	?	+	+	+
3	„	„	51	15	—	—	+	+	+
4	„	„	50	20	—	—	+	+	+
5	„	„	51	25	—	—	+	+	+
6	„	„	50	30	—	—	—	—	—
7	„	„	50—51	60	—	—	s	s	+
8	„	„	50—52	120	—	—	—	—	—
9	„	„	50—52	180	—	—	—	—	—
10	„	„	50—52	240	—	—	—	—	—
11	„	„	49—53	300	—	—	—	—	—
12	20°	35	50	5	—	—	?	?	+
13	„	„	50	10	—	—	+	+	+
14	„	„	50	15	—	—	+	+	+
15	„	„	51	20	—	—	—	—	—
16	„	„	50	25	—	—	s	s	+
17	„	„	50—51	30	—	—	—	—	—
18	„	„	51—52	60	—	—	s	+	+
19	„	„	50—51	120	—	—	—	—	—
20	„	„	48—51	180	—	—	—	—	—
21	„	„	48—51	240	—	—	—	—	—
22	„	„	47—51	300	—	—	—	—	—
23	—	—	—	0	+	+	+	+	+
24	—	—	—	0	+	+	+	+	+
25	—	—	—	0	+	+	+	+	+

Age approx. 8 hours.

Nos. 1-25 from approximately 8-hour-old, clearly unclear culture after dilution with equal parts of broth, so that the mixture from which the drops were taken was almost completely clear. Since I did not note how long elapsed between dilution and illumination, it is unclear whether the culture should be assumed to be 8 hours old or completely fresh.

Series 17. (28/4.99.)

No.	Tr.	A.	V.	Sec.	1 T.	2 T.	3 T.
1	30°	35	51	5	—	?	+
2	„	„	51	10	—	—	—
3	„	„	50—51	20	?	+	+
4	„	„	51	30	—	+	+
5	„	„	51—52	40	—	+	+
6	„	„	50	50	—	+	+
7	„	„	50—51	60	—	+	+
8	„	„	49—51	120	—	—	—
9	25°	35	51	5	?	+	+
10	„	„	51	10	?	+	+
11	„	„	51	20	—	+	+
12	„	„	51	30	s	+	+
13	„	„	50	40	—	+	+
14	„	„	51	50	s	+	+
15	„	„	50—51	60	—	+	+
16	„	„	49—51	120	—	—	—
17	35°	35	50	5	+	+	+
18	„	„	50	10	+	+	+
19	„	„	50	20	+	+	+
20	„	„	50—51	30	—	+	+
21	„	„	50	40	s	+	+
22	„	„	50	50	s	+	+
23	„	„	50—51	60	s	+	+
24	—	—	—	0	+	+	+
25	—	—	—	0	+	+	+

Age approx. 8.5 hours.

Nos. 1-25: From 24-hour-old culture, 8 and 9 hours before the start of the experiments, two platinum loops (otherwise only r) are inoculated into 2 cm³ of sterile broth; the drops are taken from this immediately before the start of the experiments.

Nos. 8 and 16 are inoculated with sterile broth on the 3rd day; this remains sterile

Series 18. (2/5.99.)

No.	Tp.	A.	V.	Sec.	14 hrs.	22 hrs.	30 hrs.	4 t.	5 t.	
1	30°	—	—	0	+	+	+	+	+	Age 7 hours.
2	„	35	50	1	+	+	+	+	+	
3	„	„	50	10	—	s	s	+	+	
4	„	„	52	20	—	s	s	s	s	
5	„	„	51—52	40	—	—	s	s	s	
6	„	„	51—52	60	—	—	?	?	+	
7	„	„	50—52	90	—	—	s	s	s	
8	„	„	49—52	120	—	—	—	—	—	
9	„	„	48—51	150	—	—	—	s	s	
10	„	35—36	47—51	180	—	—	—	—	—	
11	30°	—	—	0	+	+	+	+	+	Age 5 hours.
12	„	—	—	0	+	+	+	+	+	
13	„	35	50	ca. 0.1	+	+	+	+	+	
14	„	„	50	1	+	+	+	+	+	
15	„	„	50	5	—	+	+	+	+	
16	„	„	50	10	—	+	+	+	+	
17	„	„	50—51	20	—	+	+	+	+	
18	„	„	50	40	—	—	—	—	—	
19	„	„	50—52	60	—	s	+	+	+	
20	„	„	50—51	90	—	—	—	—	—	
21	„	„	49—52	120	—	—	—	—	—	
22	„	„	48—51	150	—	—	—	—	—	
23	„	„	50—53	180	—	—	—	—	—	

Nos. 1-10 from a culture started at 1:30 a.m., Nos. 11-23 at 4:00 a.m. Illumination began at 8:30 a.m., completed at 9:30 a.m. The sequence of experiments: 1, 2, 3, 11, 12, 13, 14, 15, 4, 17, 5, 18, etc. Both cultures are sown from one and the same culture; this was 24 hours old at the time. Thermostat 220.

Culture 1-10 is therefore just over 7 hours old, culture 11-23 about 5 hours old. Nos. 8, 10, 20-23 are inoculated into sterile broth on the 5th day; this remained sterile

Series 19. (6/5.99.)

No.	Tp.	A.	V.	Sec.	16 hrs.	22 hrs.	2 t.	
1	30°	35	50	1	+	+	+	Dilution 10 / 2 cm³
2	„	„	50	2	+	+	+	
3	„	„	51	3	+	+	+	
4	„	„	52	4	+	+	+	
5	„	„	50	5	+	+	+	
6	„	„	50	60	?	+	+	
7	„	„	51—52	120	—	+	+	
8	„	„	50—51	180	—	+	+	
9	30°	35	50	1	+	+	+	Dilution 30 2 cm³
10	„	„	50	2	+	+	+	
11	„	„	51	4	+	+	+	
12	„	„	50	5	+	+	+	
13	„	„	52	60	+	+	+	
14	„	„	51—52	120	—	+	+	
15	„	„	50—52	180	—	—	—	
16	30°	35	50	1	+	+	+	12 O Dilution 2 cm³
17	„	„	50	2	+	+	+	
18	„	„	51	3	+	+	+	
19	„	„	51	4	+	+	+	
20	„	„	50	5	?	+	+	
21	„	„	50—52	60	—	+	+	
22	„	„	50—51	120	—	+	+	
23	„	„	50—51	185	—	—	—	
24	30°	—	—	0	+	+	+	
25	„	—	—	0	+	+	+	

No. 15 appears sterile even after inoculation. Nos. 1-8: 1 loop from an eight-day culture, which had already begun to turn red on the surface (room temp.), is transferred to 2 cm³ of sterile broth, from which, after shaking, the drops are immediately settled and illuminated. Nos. 9-15: 3 loops, incidentally ditto. — Nos. 16-25: 12 loops, incidentally ditto. Nos. 24-25 are placed for 3 minutes in 300 ml of water without illumination. Experimental order: 1, 9, 16, 2, 10, 17, etc. The safe killing limit was not reached. Finsen,
Medical Light Institute.

Series 20. (14/5.99.)

No.	Tr.	A.	V.	Sec.	14 hrs.	14 St.	19 St.	24	44 hrs.	3 T.	5 T.	
1	30°	—	—	0	+	+	+	+	+	+		2 hours.
2	„	35	50	10	+	+	+	+	+	+		
3	„	„	50	30	+	+	+	+	+	+		
4	„	„	50—51	60	—	s	s	+	+	+		
5	„	„	50—51	120	—	—	—	—	—	—		
6	„	„	49—52	180	—	—	—	—	—	—		
7	30°	—	—	0	+	+	+	+	+	+		6 hours.
8	„	35	50	10	+	+	+	+	+	+		
9	„	„	51—52	30	?	+	+	+	+	+		
10	„	„	51—53	60	—	?	+	+	+	+		
11	„	„	50—53	120	—	—	—	—	—	—		
12	„	„	50—52	180	—	—	—	—	—	—		
13	30°	—	—	0	+	+	+	+	+	+		1 to 2 months.
14	„	35	50	10	+	+	+	+	+	+		
15	„	„	51—52	30	+	+	+	+	+	+		
16	„	„	51—53	60	—	+	+	+	+	+		
17	„	„	50—53	120	—	—	—	+	+	+		
18	„	„	50—52	180	—	—	—	+	+	+		
19	„	„	47—50	240	—	—	—	—	—	—		
20	„	„	48—51	300	—	—	—	—	—	—		
21	„	„	49—52	360	—	—	—	—	—	—		

Nos. 1-6: Approx. 2 tubes of old culture, sown from 24 tubes of old culture (2 loops). Clear at the beginning of the experiments.

Nos. 7-12: Approx. 6 tubes of old culture, 2 loops sown from the same culture as 1-6. Slightly cloudy at the beginning of the experiments.

Nos. 13-21: From a 1- to 2-month-old culture, which was bright red with sediment, above which a clear liquid; the latter was decanted and the sediment was transferred to 2 cm³ of sterile broth, which did not appear noticeably cloudy afterwards; the drops were taken from this.

8-12 and 14-21 were illuminated in pairs next to each other (8 next to 14, 9 next to 15, 10 next to 16, etc.).

In the following series of experiments (Series 21), the investigation into the influence of the age of the culture is continued by illuminating cultures with ages of 4-5 days, 11 hours, and 4 hours; and the investigation into the influence of the number of bacteria per unit volume, begun in Series 19, is continued. One could not, in fact, rule out a priori the possibility that the greater resistance of older cultures might be due to the fact that the bacteria in these were so numerous that they shaded each other. Two dilutions of the same culture were therefore prepared, so that one (Nos. 20-24) had to contain approximately 25 times as many bacteria per cubic millimeter as the other (Nos. 15-19). Furthermore, the two older cultures (Nos. 1-14) were diluted so strongly that they were completely clear to the naked eye appeared.

From row 21 onwards, several drops of equal value are placed side by side on the same covering quartz

can be screwed into the center of the ring that supports the apparatus.

The reason for such a cursory discussion of these investigations is that the Light Institute has recently been working diligently on new lamps with various types of electrodes. These lamps initially seemed to promise much, but did not live up to expectations. They have since taught us that more precise investigations into the ability of individual types of rays to penetrate tissue are necessary, and that there is little point in continuing to work on lamps until this question is completely clarified. In any case, all probability indicates that the future will bring better lamps, since the lamps currently in use are constructed only for the purpose of illumination, but not with the aim of causing inflammation and killing bacteria. Once it becomes clear to the experts in this field that they must construct something new for medical use, progress will surely follow

The second way to improve the method is to improve the apparatus. I have said a lot about this previously and will therefore be brief. Although the forms we currently use have emerged from the most careful investigations, it would be presumptuous to believe that they could not be improved in some respects.

--both the solar apparatus, the electrical collecting apparatus, and the printing apparatus, but what these improvements should consist of is not so easy to say at the moment. One of the most natural improvements, on which we have been working for some time, would be to treat a larger area at once, that is to say

to arrange the apparatus and lamps so that the light spots become larger without reducing the intensity of the light. With the usual apparatus with lenses of 7 cm diameter, one would have a spot of 7 cm in diameter, instead of the current one of 1/2 cm Diameter, if one were to place a flat plate of rock crystal in the lowest part of the tube instead of a convex lens. To achieve the same effect, the intensity of the light must, of course, be significantly increased at the same time. Such an enlargement of the light spot would be very advantageous for widespread cases, but unnecessary for less widespread ones. We will therefore probably have apparatuses with light spots of different sizes in the future, so that, as we have already arranged, one has light spots of different intensities

very practical improvement was recently made by A Dr. Reyn. Since the lens closest to the light often cracks, Dr. Reyn came up with the idea of cooling it with water. This is done by placing a flat rock crystal plate 2 cm in front of the uppermost lens. In the space created by this, there is distilled water, which is constantly cooled by a water stream circulating around it. This prevents the precious lenses from cracking, but also brings the entire apparatus closer to the light, and this can thus be better utilized.

The Application of the Method in Practice.

While I have dealt exclusively with the physical part of the method in the previous section,

Series 22.

No.	Tr.	A.	V.	Sec.	12 hrs.	19 hrs.
1	15°	35	49	30	— —	s s
2	"	"	52	40	— —	s —
3	"	"	51	50	— —	s —
4	"	35 (38)	53 (49)	60	— —	— —
5	"	35	51—52	70	— —	s —
6	"	"	52—53	80	— —	— —
7	"	"	52—53	90	— —	— ?
8	"	"	51 53	100	— —	— —
9	"	"	50—52	110	— —	— —
10	"	"	50—53	120	— —	— —
11	"	"	51—53	135	— —	— —
12	"	"	40—51	150	— —	— —
13	35°	35	51	30	— —	s s
14	"	"	50	40	— —	— —
15	"	"	51	50	— —	— —
16	"	"	50—51	60	— —	— —
17	"	"	50—51	70	— —	— —
18	"	"	50—51	80	— —	— —
19	"	"	49—51	90	— —	— —
20	"	"	50—52	100	— —	— —
21	"	"	50—53	110	— —	— —
22	"	"	50—52	120	— —	— —
23	"	"	51—52	135	— —	— —
24	"	"	51—53	150	— —	— —
25	35°	—	—	0	+ + + +	+ + + +

No. 4. In the last 5 seconds, 38 A. and 49 V.
Nos. 1-25: From 6 s of old, just cloudy broth culture, 1 loop is sown in 2.0 sterile broth 6 s before the start of the experiments; this broth is

($\frac{27}{5}$. 99.)

25 hrs.	36 hrs.	44 hrs.	66 hrs.	80 hrs.	90 hrs.	Sec.	
s s / s s	s s / s s	s s / s s	s s / + +	s s / + +	s s / + +	30	15° Age approx. 6 hours.
s s	s s	s s	+ +	+ +	+ +	40	
s s	s s	s s	+ +	+ +	+ +	50	
— —	— —	— —	— —	— —	— —	60	
— —	— s	— s	— +	— +	— +	70	
— —	— —	— —	— —	— —	— —	80	
s —	s —	s —	+ —	+ —	+ —	90	
— —	— —	— —	— —	— —	— —	100	
s s	s s	s s	+ +	+ +	+ +	110	
— s	— s	— s	— +	— +	— +	120	
— —	— —	— —	— —	— —	— —	135	
— —	— —	— —	— —	— —	— —	150	
s / s s	s / s s	s / s s	s / s s	s / s s	s / s s	30	35° Age approx. 6 hours,
— —	— —	— —	— —	— —	— —	40	
— —	— —	— —	— —	— —	— —	50	
— —	— —	— —	— —	— —	— —	60	
— —	— —	— —	— —	— —	— —	70	
— —	— —	— —	— —	— —	— —	80	
s —	s —	s —	s —	s —	s —	90	
— —	— —	— —	— —	— —	— —	100	
— —	— —	— —	— —	— —	— —	110	
— —	— —	— —	— —	— —	— —	120	
— —	— —	— —	— —	— —	— —	135	
— —	— —	— —	— —	— —	— —	150	
+ + / + +	+ + / + +	+ + / + +	+ + / + +	+ + / + +	+ + / + +	0	

placed at 220. From this 6-hour-old culture, 4 drops are placed on each cover quartz, with the exception of 1 and 13, where only 3 are deposited.
Nos. 18 and 22 were clearly red only after 90 hours

Row 23.

No.	Tp.	A	v.	Sek.	11 St.	17 St.	20 St.
1	18°	35	52	30	— — / — —	— — / — s	— — / — s
2	19°	"	52	40	— — / — —	— — / — —	— — / — —
3	6,50 p.m	"	50—52	50	— — / — —	— — / — —	— — / — —
4	18°	"	52—54	60	— — / — —	— — / — —	— — / s —
5	"	"	50—51	70	— — / — —	— — / — —	— — / — —
6	"	"	50—51	80	— — / — —	— — / — —	— — / — —
7	"	"	51	90	— — / — —	— — / — —	— — / — —
8	"	"	51—52	100	— — / — —	— — / — —	— — / — —
9	"	"	51	110	— — / — —	— — / — —	— — / — —
10	"	"	50—51	120	— — / — —	— — / — —	— — / — —
11	"	"	51—52	150	— — / — —	— — / — —	— — / — —
12	36°	"	50	20	— — / — —	s — / — —	s — / — —
13	36,5°	"	50—51	30	— — / — —	s — / — —	s — / — —
14	"	"	50—51	40	— — / — —	— — / — —	— — / — —
15	36°	"	51	50	— — / — —	— — / — —	— — / — —
16	36,5°	"	51	60	— — / — —	— — / — —	— — / — —
17	36°	"	51—53	70	— — / — —	— — / — —	— — / — —
18	"	"	51—52	80	— — / — —	— — / — —	— — / — —
19	"	"	50—54	90	— — / — —	— — / — —	— — / — —
20	"	"	50—54	100	— — / — —	— — / — —	— — / — —
21	"	"	50—53	110	— — / — —	— — / — —	— — / — —
22	"	"	50—54	120	— — / — —	— — / — —	— — / — —
23	"	—	—	0	+ + / + +	+ + / + +	+ + / + +

Five hours before the start of the experiment, a loop of a 24-hour-old broth culture is sown in 2.0 broth; this latter culture, from which the drops are deposited immediately before the experiment, has been kept at 28°C (i.e., room temperature). The illumination began at 8:45°C, ended at 9:45°C, and was carried out in numerical order (12-23 being half to a full hour older than 1-11 at the moment they were illuminated).

(6/7. 99.)

23 St.	35 St.	42 St.	47 St.	3T.	4T.	5 T.	Sek.	
s s / — s	s s / s s	s s / s s	s s / s s	s s / s s	s s / s s	s s / s s	30	180. Age approx. 514 years.
— — / — s	— s / — s	— s / — s	— s / — s	— s / — s	— s / — s	— + / — s	40	
s — / — —	s — / — —	s s / — —	s s / — —	s s / — —	s s / — —	+ + / — —	50	
— — / s —	— s / s —	s s / s —	s s / s —	s s / s —	s s / s —	s s / s —	60	
— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	70	
— — / — —	s — / — —	s — / — —	s — / — —	s — / — —	s — / — —	s — / — —	80	
— s / — —	— s / — —	— s / — —	— s / — —	— s / — —	— s / — —	— s / — —	90	
— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	— — / s —	— — / — s	100	
— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	110	
— — / — —	— — / — —	s — / — —	s — / — —	s — / — —	s — / — —	s — / — —	120	
— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	150	
s s / s s	s s / s s	s s / s s	s s / s s	s s / s s	s s / s s	s s / s s	20	36°. Age approx. 5 3/4 hours.
s s / s —	s s / s —	s s / s —	s s / s —	s s / s —	s s / s —	s s / s —	30	
— — / — —	— — / s —	— — / s —	— — / s —	— — / s —	— — / s —	— — / s —	40	
— — / — —	— — / — s	— — / — s	— — / — s	— — / — s	— — / — s	— — / — s	50	
— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	60	
— — / — —	s — / — —	s — / — —	s — / — —	s — / — —	s — / — —	s — / — —	70	
— — / — —	— — / — —	s — / — —	s — / — —	s — / — —	s — / — —	s — / — —	80	
— — / — —	— — / — —	— s / — —	— s / — —	— s / — —	— s / — —	— s / — —	90	
— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	100	
— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	110	
— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	120	
+ + / + +	+ + / + +	+ + / + +	+ + / + +	+ + / + +	+ + / + +	+ + / + +	0	

No. 23 was placed in water at 36°C for 30 seconds without illumination. The 4 drops on each cover quartz.
temperature could only be brought slightly below 180°C without damaging the quartz.
window was dewed due to the humidity of the atmosphere.

Series 24.

No.	Tr.	A.	V.	Sec.	11 h.	17 h.
1	$16._5{}^0$	35	50	1	− −	+ +
2	"	"	51	2	− −	+ +
3	"	"	50	3	− −	+ +
4	"	"	50	5	− −	− −
5	"	"	51	7	− −	− −
6	"	35—$36._5$	50—51	9	− −	− −
7	"	35	51	11	− −	− −
8	"	"	51	13	− −	− −
9	"	"	50	15	− −	− −
10	"	"	51—53	50	− −	− −
11	"	"	51	60	− −	− −
12	"	"	49—52	70	− −	− −
13	36^0	35	50	1	− −	+ +
14	"	"	52	2	− −	? ?
15	"	"	51	3	− −	s s
16	"	"	51	5	− −	? ?
17	"	35—34	53	7	− −	− −
18	"	35	51	9	− −	− −
19	"	"	51	11	− −	− −
20	"	"	51	13	− −	− −
21	"	"	50	15	− −	− −
22	"	"	51	50	− −	− −
23	"	"	51	60	− −	− −
24	"	34—35	51—53	70	− −	− −
25	36^0	—	—	0	+ +	+ +

Nos. 1-25: From 24 pcs. of old broth culture, a loop is sown in 2.0 broth 3 pcs. before the start of the experiments.

($1^0/_7$. 99.)

23 h.	38 h.	41 h.	45 h.	65 h.	Sec.	
+ +	+ +	+ +	+ +	+ +	1	16° Age approx. 3 hours.
+ +	+ +	+ +	+ +	+ +	2	
+ +	+ +	+ +	+ +	+ +	3	
+ +	+ +	+ +	+ +	+ +	5	
+ +	+ +	+ +	+ +	+ +	7	
? ?	+ +	+ +	+ +	+ +	9	
+ +	+ +	+ +	+ +	+ +	11	
+ −	+ +	+ +	+ +	+ +	13	
− −	− −	+ −	+ −	+ −	15	
? ?	+ +	+ +	+ +	+ +	50	
− −	s ?	s −	s +	+ +	60	
? ?	+ +	+ +	+ +	+ +	70	
− −	? −	+ −	+ −	+ −		
+ ?	+ s	+ s	+ s	+ +		
− −	− +	− +	− +	− +		
− −	+ −	+ −	+ −	+ −		
− −	? −	+ −	+ −	+ −		
− −	− −	− −	? −	+ −		
− −	− −	− −	− −	− −		
− −	− −	− −	− −	− −		
+ +	+ +	+ +	+ +	+ +	1	360 Age approx. 3.5 hours.
+ +	+ +	+ +	+ +	+ +	2	
+ +	+ +	+ +	+ +	+ +	3	
+ +	+ +	+ +	+ +	+ +	5	
? +	s +	s +	s +	s +	7	
+ ?	+ s	+ s	+ s	+ s	9	
+ +	+ +	+ +	+ +	+ +	11	
? ?	+ +	+ +	+ +	+ +	13	
? ?	s +	s +	+ +	+ +	15	
− −	+ +	+ +	+ +	+ +	50	
− −	+ −	+ −	+ −	+ −	60	
− +	− +	+ +	+ +	+ +	70	
− −	− +	− +	− +	− +		
− +	− +	− +	− +	− +		
− −	s −	s −	s −	+ −		
− −	− s	− s	− +	− +		
− −	− −	− −	− −	− −		
− −	− −	− −	− −	− −		
− −	− −	− −	− −	− −		
− −	− −	− −	− −	− −		
+ +	+ +	+ +	+ +	+ +	0	
+ +	+ +	+ +	+ +	+ +		

4 drops on each quartz.
After illumination, the drops are placed in an unheated thermostat

Series 25 (contaminated culture). (12/7/99)

No.	Tb.	A.	V.	Sec.	13 h.	17 h.	22 h.	37 h.	39 h.	46 h.	3 T.	4 T.	Sec.	
1	36°	35	50—51	20	— —	? —	s —	s —	s —	+ —	+ —	+ —	20	36° Age 3.5 Hours.
2	„	„	51	30	— —	s —	s s	s s	s s	+ s	+ s	+ s	30	
3	„	„	50	40	— —	— —	— —	— —	— —	— —	— —	— —	40	
4	„	„	50	50	— —	— —	— —	+ s	+ s	+ s	+ s	+ s	50	
5	„	„	51—52	60	— —	— —	— —	— —	— —	— —	— —	— —	60	
6	„	„	51—52	70	— —	— —	— —	— +	— +	— +	— +	— +	70	
7	„	„	50—51	80	— —	— —	— —	— +	— +	— +	— +	— +	80	
8	„	„	51—53	90	— —	— —	— —	— —	— —	— —	— —	— —	90	
9	„	„	51—53	100	— —	— —	— —	— —	— —	— —	— —	— —	100	
10	„	„	51—53	110	— —	— —	— —	— —	— —	— —	— —	— —	110	
11	26°	35	50	20	— —	? —	+ +	+ +	+ +	+ +	+ +	+ +	20	26° Age 4 Hours.
12	„	„	52	30	— —	— —	+ —	+ —	+ —	+ —	+ —	+ —	30	
13	„	„	53	40	— —	— —	— —	+ —	+ —	+ +	+ +	+ +	40	
14	„	„	51—52	50	— —	— —	— —	— s	— +	— +	— +	— +	50	
15	„	„	51—53	60	— —	— —	— —	— —	— —	— —	— —	— —	60	
16	„	„	50—53	70	— —	— —	— —	— —	— —	— —	— —	— —	70	
17	„	„	50—52	80	— —	— —	— —	— —	— —	— —	— —	— —	80	
18	„	„	50—52	90	— —	— —	— —	— —	— —	— —	— —	— —	90	
19	„	„	51—52	100	— —	— —	— —	— —	— —	— —	— —	— —	100	
20	„	„	52—53	110	— —	— —	— —	— —	+ —	+ —	+ —	+ —	110	
21	16.5°	35	51—53	20	— —	+ —	+ —	+ —	+ —	+ —	+ —	+ —	20	16° Age 5 Hours
22	„	„	50—51	30	— —	— —	— —	s —	+ —	+ —	+ —	+ —	30	
23	„	„	52	40	— —	— —	— —	— —	— —	— —	— —	— —	40	
24	„	„	50	50	— —	— —	— —	— —	— —	— —	— —	— —	50	
25	„	„	50—51	60	— —	— —	— —	— —	— —	— —	— —	— —	60	
26	„	„	50—51	70	— —	— —	— —	— —	— —	— —	— —	— —	70	
27	„	„	50—52	80	— —	— —	— —	— —	— —	— —	— —	— —	80	
28	„	„	49—52	90	— —	— —	— —	— —	— —	— —	— —	— —	90	
29	„	„	50	100	— —	— —	— —	— —	— —	— —	— —	— —	100	
30	„	„	50—51	110	— —	— —	— —	— —	— —	— —	— —	— —	110	
31	36°	—	—	0	+ +	+ +	+ +	+ +	+ +	+ +	+ +	+ +	0	

Nos. 1-31: From 28 s. of old broth culture, one loop is sown in 2.0 s. of broth at 6 o'clock (i.e., 3.5 hours before the start of the experiments), from which the drops, 4 on each quartz, are deposited at 9-9.12: First, preparation 1, then 31, then 2, then 30, etc., are prepared. Illumination in numerical order, beginning at 9.5, ending at 11 o'clock. Age, therefore, 3.5-5 s. No. 3: The attack in the two drops is caused by contamination by means of a small cotton thread. No. 2: Inoculation of the drops confirms their sterility

Nos. 5, 6, and 20 are inoculated with broth in a test tube; the culture that subsequently emerges shows, in addition to Prodigiosus, a foreign bacillus in all three cases. The remaining drops were discarded at this point

Row 26. (14/7.99.)

64 drops were deposited, which, with the exception of 4 control drops, were illuminated in 10-20 seconds. All remained sterile, and it turned out that the drops had been taken from sterile broth by mistake.

Row 27. (7/7. 99.)

No.	Tr.	A.	V.	Sec.	14 h.	20 h.	40 h.	3 d.	4 t.	5 t.	Sec.	
1	30°	35—36	51—52	30	s + / — —	s + / s —	s + / + +	+ + / + +	+ + / + +	+ + / + +	30	A 1 Age 13 3/4 hours.
2	„	35	52—53	60	— — / — —	+ s / — s	+ + / + +	+ + / + +	+ + / + +	+ + / + +	60	
3	„	„	50—52	120	— — / — —	— — / — s	+ + / — +	— — / — +	— — / + —	— + / + —	120	
4	„	„	50—54	180	— — / — —	s — / — —	+ — / + —	+ — / + —	+ — / + —	+ — / + —	180	
5	„	„	50—54	240	— — / — —	s — / — —	+ — / — —	+ — / — —	+ — / — —	+ — / — —	240	
6	„	„	50—54	360	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	300	
7	30°	—	—	0	+ + / + +	+ + / + +	+ + / + +	+ + / + +	+ + / + +	+ + / + +	0	B Age 614 hours.
8	„	35—36	51—52	30	— — / — —	s s / — s	s s / — s	s s / — s	s s / — s	s s / — s	30	
9	„	35	52—53	60	— — / — —	— s / — —	— s / s s	— s / s s	— s / s s	— s / s s	60	
10	„	„	50—54	90	— — / — —	— — / — —	— — / s —	— s / s —	— s / s —	— s / s —	90	
11	„	„	50—52	120	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	120	
12	„	„	50—54	180	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	180	
13	30°	—	—	0	+ + / + +	+ + / + +	+ + / + +	+ + / + +	+ + / + +	+ + / + +	0	C Age 4 hours.
14	„	35	51	30	— — / — —	s — / s —	s — / s —	s — / s —	s — / s —	s — / s —	30	
15	„	35·5	50—53	45	— — / — —	— s / s —	— s / s —	— s / s —	— s / s —	— s / s —	45	
16	„	35	51—52	60	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	60	
17	„	„	50—54	90	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	90	
18	„	„	52—53	120	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	120	
19	„	35—36	50—53	150	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	— — / — —	150	

No. 1-19: From a completely red culture, started on July 14, one loopful in 2.0 broth is inoculated on July 16 at 6:00 p.m. From this, one loopful in 2.0 broth is inoculated this morning at 8:00 a.m., since a narrow red border is already visible on the surface A) inoculated. At 3.5 p.m., 2 loops of A were inoculated into 2.0 broth (Glass B), and at 6.4 p.m., 2 loops of A were inoculated into 2.0 broth (Glass C). (The room temperature at 7 p.m. was still 26°C.)

Drops of B and C are added between 8.5 and 9 p.m. to Nos. 7-12 and 13-19. At 9.5 p.m., 0.06 cm³ of A is transferred into 2.0 broth, which then appears unchanged and clear (Glass A1). (A itself had long since become cloudy.) Nos. 1-6 are added from A1. Illumination begins at 9.30 a.m. and ends at 10.30-

Order of illumination (2 at a time): (1, 8), (2, 9), (3, 11), (10, 17), (4, 12), 5, 6, 14, 16, 18, 15, 19. The age of A1, when illuminated, is therefore 13.5-14 hours, of B 6-6.5 hours, of C 3.4-4.5 hours.

The numbering order of Nos. 14-19 is not entirely certain, as some may have been swapped during the second viewing

Series 28. (20/7.99.)

No.	Tp.	A.	V.	Sec.	17 St.	40 St.	3 T.	4 T.	6 T.	
1	30°	—	—	0	++ ++	++ ++	++ ++	++ ++	++ ++	C. Age approx. 2 3/4 hours.
2	„	$34_{.5}$-$35_{.5}$	50—52	40	— —	s s	++ ++	++ ++	++ ++	
3	„	35	51—52	60	— —	s —	+ —	+ —	+ —	
4	„	„	50—52	80	— —	— —	— —	— —	— —	
5	„	„	50—52	100	— —	— —	— —	— —	— —	
6	„	„	50—53	120	— —	— —	— —	— —	— —	
7	„	„	51—54	180	— —	— —	— —	— —	— +	
8	30°	—	—	0	++ ++	++ ++	++ ++	++ ++	++ ++	B. Age approx. 7 1/4 hours.
9	„	$34_{.5}$-$35_{.5}$	51—52	60	— —	s —	s —	s —	s —	
10	„	35	50—52	80	— —	— —	— —	— —	— —	
11	„	„	50—52	100	— —	s —	+ —	+ —	+ —	
12	„	„	50—53	120	— —	— —	— —	— —	— —	
13	„	„	51—54	180	— —	— —	— —	— —	— —	
14	„	„	51—54	240	— —	— —	— —	— —	— —	
15	30°	—	—	0	++ ++	++ ++	++ ++	++ ++	++ ++	A¹. Age approx. 12 3/4 hours.
16	„	35	50—52	60	— —	— +	— +	— +	— +	
17	„	„	50—52	120	— —	— —	— —	— —	— —	
18	„	„	50—53	180	— —	+ +	+ +	+ +	+ +	
19	„	„	50—54	210	— —	— +	— +	— +	— +	
20	„	„	49—53	240	— —	— +	— +	— +	— +	
21	„	„	50—54	300	— —	— —	— +	— +	— +	

From an 18-hour-old culture, inoculate at 8 a.m. into 2.0 broth (tube A). From A, 1 loop is inoculated at 1.5 a.m. into 2.0 broth (tube B). From A, 1 loop is inoculated at 6 a.m. into 2.0 broth (tube C).

Nos. 1-7 from tube C, Nos. 8-14 from tube B.

Immediately before the start of the experiments, 0.02 cm³ of tube A is transferred into 2.0 broth; this appears unchanged and clear afterwards, and from this, Nos. 15-21 are separated

Glass B was noticeably cloudy at the start of the experiments, glass C was still clear. Illumination began at 8:30 and ended at 9:10.

Illumination order (sometimes two at the same time): 2, (3, 9), (4, 10), (5, 11), 6, 12), (7, 13), (14, 20), 11, 17, 18, 19, 21.

age of Nos. 1-7 is therefore 2.5-3 hours, of Nos. 8-14-7-7.5 hours, of Nos. 15-21-12.5-13 hours at illumination

Series 29 (50% Broth). (24/7.99.)

No.	T.	A.	V.	Sec.	1 T. 3 T. 4 T.			5 T.	
1	30°	35	50—52	180	— —	s —	s —	s —	Age 13 hours
2	„	„	49—52	210	— —	s —	s —	¹ —	
3	„	„	50—52	247	— —	— —	— —	— —	
4	„	„	50—52	270	— —	— s	— s	— s	
5	„	„	49—52	300	— —	— s	— s	— s	
6	30°	35	50—51	40	— —	s s	s s	s s	Age 71 hours.
7	„	„	50—51	80	— —	— s	— s	— s	
8	„	„	50—52	100	— —	— —	— —	— —	
9	„	„	50—52	120	— —	— —	— —	— —	
10	„	„	50—52	150	— —	s —	s —	s —	
11	„	„	50—52	180	— —	— —	— —	— —	
12	„	—	—	0	? ?	++	++	++	
13	30°	—	—	0	? ?	++	++	++	Age 3.5 hours.
14	„	35	50—51	40	— —	s s	s s	s s	
15	„	„	50	60	— —	— s	— s	— s	
16	„	„	50—51	80	— —	s s	s s	s s	
17	„	„	50—52	100	— —	— s	— s	— s	
18	„	„	50—52	120	— —	— —	— —	— —	
19	„	„	50—52	150	— —	— —	— —	— —	

In this series, a broth diluted with equal parts of distilled water was used experimentally to achieve a lighter color. However, it turned out that the bacteria grew considerably more slowly and sparsely in this mixture than usual, which is why this mixture was not used further. Nos. 1-5 were 13 hours old at the start of illumination.

Before the drops were deposited, they were diluted so much that they remained completely clear. Nos. 6-12 are 7.5 hours old, and Nos. 13-19 are 3.5 hours old. Possibly, some of the drops marked * were not sterile, because even the 8 control drops (Nos. 12 and 13) were so slightly cloudy that it was difficult to see with the naked eye.

Row 30. (31/7.99.)

No.	Tp.	A	v.	Sek.	15 St.	36 St.	3T.	4T.	
1	30°	—	—	0	+ + / + +	+ + / + +	+ + / + +	+ + / + +	A Age 4 hours.
2	„	35	51—52	20	— — / — —	s s / s s	s s / s s	s s / s s	
3	„	„	51	40	— — / — —	— s / s s	— s / s s	— s / s s	
4	„	„	50—51	60	— — / — —	— — / — s	— — / s s	— — / s s	
5	„	„	50—52	90	— — / — —	— — / — —	— — / — —	— — / — —	
6	„	„	50—52	120	— — / — —	— — / — —	— — / — —	— — / — —	
7	„	—	—	0	+ + / + +	+ + / + +	+ + / + +	+ + / + +	B Age 6 hours.
8	„	35	50—51	20	— — / — —	s s / s s	s s / s s	s s / s s	
9	„	„	51	40	— — / — —	— — / — —	— s / — s	— s / — s	
10	„	„	50—51	60	— — / — —	s — / — s	s — / — s	s — / — s	
11	„	„	50—52	90	— — / — —	— — / — —	— — / — —	— — / — —	
12	„	„	50—52	120	— — / — —	— s / — —	— s / — —	— s / — —	
13	„	„	51—52	60	— — / — —	— — / — —	— — / — —	— — / — —	C Age 814 hours.
14	„	„	51—52	90	— — / — —	s s / — —	s s / — —	s s / — —	
15	„	„	51—52	120	— — / — —	— — / — —	— — / s —	— — / s —	
16	„	„	50—52	160	— — / — —	— s / — —	s — / — —	s — / — —	
17	„	„	50—52	210	— — / — —	— — / — —	— — / — —	— — / — —	
18	„	„	50—52	270	— — / — —	— — / — —	— — / — —	— — / — —	

From a culture that had been continuously re-bred through four generations before pigment became visible, and which was 8 hours old on July 31st at 8 a.m., all tubes A, B, C, D, E, and F were inoculated. Inoculation took place at 8 a.m. in F, 10 a.m. in E, 12 p.m. in D, 2 p.m. in C, 4 a.m. in B, and 6 p.m. in A.

(Series 30 continued)

No.	Tp.	A	v.	Sek.	15 St.	36 St.	3 T.	4 T.	
19	30°	35	51—52	60	— — / — —	— s / — —	s s / s —	s s / s —	D Age 1014 hours.
20	„	„	51—52	90	— — / — —	— — / — —	— s / s —	— s / s —	
21	„	„	51—52	120	— — / — —	— — / — —	s — / — —	s — / — —	
22	„	„	50—52	160	— — / — —	— — / — —	— — / — —	s — / — —	
23	„	„	50—52	210	— — / — —	— — / — —	— — / — —	— — / — —	
24	„	„	50—52	270	— — / — —	— — / — —	— — / — —	— — / — —	
25	„	„	50—52	120	— — / — —	— s / s —	s s / s —	s s / s —	E Age 1234 hours.
26	„	„	50—52	150	— — / — —	— — / — —	— s / s —	— s / s —	
27	„	„	50—52	180	— — / — —	— — / — —	s — / — —	s — / — —	
28	„	„	50—52	210	— — / — —	— — / — —	s — / — s	s — / — s	
29	„	„	49—52	240	— — / — —	— — / — —	s — / — —	s — / — —	
30	„	„	50—52	280	— — / — —	— — / — —	— — / — —	— — / — —	
31	„	„	50—52	330	— — / — —	— — / — —	— — / — —	— — / — —	
32	„	„	50—52	120	— — / — —	s s / s —	s s / s —	s s / s —	F Age 14.5 hours.
33	„	„	50—52	150	— — / — —	— — / — s	— s / — s	— s / — s	
34	„	„	50—52	180	— — / — —	— — / — —	s — / — —	s — / — —	
35	„	„	50—52	210	— — / — —	— — / — —	— s / — —	— s / — —	
36	„	„	49—52	240	— — / — —	s — / — —	s — / — —	s — / — —	
37	„	„	50—52	280	— — / — —	— — / — —	— — / — —	— — / — —	
38	„	„	50—52	330	— — / — —	— — / — —	— — / — —	— — / — —	

Lighting started at 9:45 p.m. and finished at 11 a.m.
Lighting order: (2, 8), (3, 9), (4, 10), (5, 11), (6, 12), (13, 19), (14, 20), (15, 21), (16, 22), (17, 23), (18, 24), (25, 32), (26, 33) etc.

Series 31. (4/s. 99.)

No.	Tr.	A.	V.	Sec.	1 T.	2 T.	3 T.	4 T.	
1	44.5^0	35	50—51	10	− − / − −	s s / s s	s s / s s	s s / s s	45° Age 3½ hours.
2	„	„	51	20	− − / − −	− s / − −	− s / − −	− s / − −	
3	„	„	51	40	− − / − −	− − / − −	− − / − −	− − / − −	
4	„	„	51	60	− − / − −	− − / − −	− − / − −	− − / − −	
5	„	„	51	90	− − / − −	− − / − −	− − / − −	− − / − −	
6	„	„	51	120	− − / − −	− − / − −	− − / − −	− − / − −	
7	„	„	50—51	160	− − / − −	− − / − −	− − / − −	− − / − −	
8	30^0	„	50	20	− − / − −	+ − / + s	+ + / + +	+ + / + +	30° Age 3.5 hours.
9	„	„	51	40	− − / − −	− s / − s	− + / − +	− + / − +	
10	„	„	51	60	− − / − −	− − / − −	− − / − −	− − / − −	
11	„	„	51	90	− − / − −	− − / − −	− − / − −	− − / − −	
12	„	„	51—52	120	− − / − −	− − / − −	− − / − −	− − / − −	
13	„	„	51—52	160	− − / − −	− s / − −	− s / − −	− s / − −	
14	45^0	—	—	0	+ + / + +	+ + / + +	+ + / + +	+ + / + +	
15	„	—	—	0	+ + / + +	+ + / + +	+ + / + +	+ + / + +	
16	„	—	—	0	+ + / + +	+ + / + +	+ + / + +	+ + / + +	

From a 4.5-hour-old culture, inoculate at 6.30 p.m. in 2.0 broth. Thermostat 25° until 8.5 p.m., when the drops began to settle. Lighting started at 9.40, ended at 10.25. Lighting in numerical order. Nos. 14 and 15 were placed in 45° water for 180 seconds, No. 16 for 300 seconds, without illumination.

The thermostat was also set to 250 for the following rows.

Series 32. (8/8. 99.)

No.	Tr.	A.	V.	Sec.	1 T.	2 T.	3 T.	8 T.	
1	15^0	—	—	0	+ + / + +	+ + / + +	+ + / + +	+ + / + +	
2	45^0	—	—	0	+ + / + +	+ + / + +	+ + / + +	+ + / + +	
3	45^0	35	50	10	− − / − −	s − / − s	s − / − s	+ − / − +	45° Age: 4 hours. Age: 3.5 hours, Age: 3 hours.
4	„	„	51	20	− − / − −	− s / − −	− s / − −	− + / − −	
5	„	„	51	40	− − / − −	− − / − −	− − / − −	− − / − −	
6	„	„	50	60	− − / − −	− − / − −	− − / − −	− − / − −	
7	„	„	50—51	90	− − / − −	− − / − −	− − / − −	− − / − −	
8	30^0	35	51	20	− − / − −	+ + / + +	+ + / + +	+ + / + +	30°
9	„	„	51	40	− − / − −	− + / + −	− + / + −	− + / + −	
10	„	„	51	60	− − / − −	− − / − −	− − / − −	− − / − −	
11	„	„	50—52	90	− − / − −	− − / − −	− − / − −	− − / − −	
12	„	„	approx. 51	120	− − / − −	− − / − −	− − / − −	− − / − −	
13	15^0	35	51	20	− − / − −	s + / + +	+ + / + +	+ + / + +	15°
14	„	„	51	40	− − / − −	− + / − −	− + / − −	− + / − −	
15	„	„	50 − 51	60	− − / − −	− + / − −	− + / − −	− + / − −	
16	„	„	51—52	90	− − / − −	− − / − −	− − / − −	− − / − −	
17	„	„	50 − 51	120	− − / − −	− − / − −	− − / − −	− − / − −	

From 6.5 h of old culture (from a 12 h old culture that grew at 250) at 6:30 p.m., inoculate into 2.0 bouillon, which is kept at 250. All drops of this are dispensed between 8:45 and 9:30. Illumination began at 9:30 and ended at 10:45, in numerical order. No. 2 was placed in 450 water for 120 seconds without illumination.

Row 33 (12/8.99).

From a culture approximately 3 hours old, 28 drops were illuminated at 450 for 10-60 seconds, 24 drops at 300 for 20-120 seconds, and 24 drops at 150 for 20-120 seconds. 12 drops served as a control without illumination. All preparations remained sterile with the exception of one of the four drops that had received 10 seconds of light at 450, one of the four that had received 20 seconds of light at 150, and the 12 control drops. However, these latter all grew very sparsely, were only "s" in the first three days, and only on the fourth day did the scattered growth centers confluent into a weak, diffuse turbidity. Why this culture was weakened from the start, I do not know

Series 34. ($^{16}/_{8}$. 99.)

No.	Tr.	A.	V.	Sec.	1 T.	2 T.	3 T.	4 T.	5 T.	7 T.	Sec.
1	45°	35	51	5	— —	S S	S S	S S	S S	S S	5
2	"	"	51	10	Koko	S S	S S	S S	S S	S S	10
3	"	"	51	15	— —	S S	S S	S S	S S	S S	15
4	"	"	51.5	20	— —	— S	— S	S S	S S	S S	20
5	"	"	51	30	— —	— —	— S	— S	— S	— S	30
6	"	"	51—52	40	— —	— —	— S	— S	— S	— S	40
7	"	"	50—51	60	— —	— —	— —	— —	— —	— —	60
8	"	"	48—52	100	— —	— —	— —	— —	— —	— —	100
9	30°	35	51	10	S S	S S	S S	S S	S S	S S	10
10	"	"	51—52	20	— —	S S	S S	S S	S S	S S	20
11	"	"	51	30	— —	S S	S S	S S	S S	S S	30
12	"	"	51	40	— —	— S	— S	— S	— S	— S	40
13	"	"	51—52	60	— —	S —	S —	S —	S —	S —	60
14	"	"	51—52	100	Koko	— —	— —	— —	— —	— —	100
15	"	"	51—52	150	— —	— —	— —	— —	— —	— —	150
16	15°	35	51	10	S S	S S	S S	S S	S S	S S	10
17	"	"	51	20	— —	S S	S S	S S	S S	S S	20
18	"	"	51	30	— —	S S	S S	S S	S S	S S	30
19	"	"	51—52	40	— —	S S	S S	S S	S S	S S	40
20	"	"	50—51	60	— —	S —	S —	S —	S —	S —	60
21	"	"	50—52	100	— —	— —	— —	— —	— —	— —	100
22	"	"	51—52	150	— —	— —	— —	— —	— —	— —	150
23	—	—	—	0	+ +	+ +	+ +	+ +	+ +	+ +	0
24	45°	—	—	0	+ +	+ +	+ +	+ +	+ +	+ +	0

From a 13.5-hour-old culture, inoculate 1.5 p.m. in 2.0 broth (tube A) and 4.45 p.m. in 2.0 broth (tube B).

Nos. 1-24 are removed from tube B immediately before the start of the experiments, and Nos. 25-49 1.5 hours earlier from tube A. Illumination began at 9.40 a.m. and ended at 11 a.m.

Illumination in numerical order, but always two at a time (1 and 25, 2 and 26, etc.).

(continued pp. 72–73)

45° Age 5 hours.

30° Age 5.5 hours.

15° Age 614 hours.

To regulate the current, a new resistor was used, consisting of 21 incandescent lamps, which were connected individually or in groups in parallel with the ordinary Rheostats are to be switched; this allows the current to be maintained so precisely at 35 amperes that the error hardly exceeds 1/10 ampere. Only during the illumination of Nos. 8 and 32 was the current 36 amperes for a few seconds, while the lamp regulated itself

(Series 34

No.	Tp.	A.	V.	Sec.	1 T.	2 T.
25	45°	35	51	5	s s / s —	s s / s s
26	„	„	51	10	s s / s —	s s / s s
27	„	„	51	15	— s / — —	s s / s s
28	„	„	51-5	20	— — / — —	s s / s s
29	„	„	51	30	— — / — —	s — / s s
30	„	„	51—52	40	— — / — —	— — / s —
31	„	„	50—51	60	— — / — —	— — / — —
32	„	„	48—52	100	— — / — —	— — / — —
33	30°	35	51	10	s s / — —	s s / s s
34	„	„	51—52	20	s — / — —	s s / s s
35	„	„	51	30	— — / — —	s s / s s
36	„	„	51	40	— — / — —	s s / s s
37	„	„	50—52	60	— — / — —	— s / — s
38	„	„	50—52	100	— — / — —	— — / s —
39	„	„	51—52	150	— — / — —	— — / — —
40	15°	35	51	10	— — / s —	s s / s s
41	„	„	51	20	— — / s s	s s / s s
42	„	„	51	30	— — / — —	s s / s s
43	„	„	51—52	40	— — / — —	s s / s s
44	„	„	50—51	60	— — / — —	s s / s s
45	„	„	50—52	100	— — / — —	— — / s s
46	„	„	51—52	150	— — / — —	— — / — —
47	—	—	—	0	+ + / + +	+ + / + +
48	45°	—	—	0	+ + / + +	+ + / + +
49	„	—	—	0	+ + / + +	+ + / + +

Nos. 24, 48, and 49 were placed in 450 ml of water without light, 24 and 48 for 2 minutes, and 49 for 3 minutes. Nos. 23 and 47 received neither heat nor light. The ages of 1: 244, 55, and 6:15 hours; of 25: 498, 10, and 9:30 hours.

continued.)

3 T.	4 T.	5 T.	7 T.	Sec.	
s s / s s	s s / s s	s s / s s	s s / s s	5	45° Age: 8.5 hours.
s s / s s	s s / s s	s s / s s	s s / s s	10	
s s / s s	s s / s s	s s / s s	s s / s s	15	
s s / s s	s s / s s	s s / s s	s s / s s	20	
s — / s s	s — / s s	s — / s s	s — / s s	30	
— — / s —	— — / s —	— — / s —	— — / s —	40	
— s / — s	— s / — s	— s / — s	— s / — s	60	
— — / — —	— — / — —	— — / — —	— — / — —	100	
s s / s s	s s / s s	s s / s s	s s / s s	10	30° Age: 8.5 hours.
s s / s s	s s / s s	s s / s s	s s / s s	20	
s s / s s	s s / s s	s s / s s	s s / s s	30	
s s / s s	s s / s s	s s / s s	s s / s s	40	
— s / s s	— s / s s	— s / s s	— s / s s	60	
— — / s —	— — / s —	— — / s —	— — / s —	100	
— — / — —	— — / — —	— — / — —	— — / — —	150	
s s / s s	s s / s s	s s / s s	s s / s s	10	15° Age: 9.5 hours.
s s / s s	s s / s s	s s / s s	s s / s s	20	
s s / s s	s s / s s	s s / s s	s s / s s	30	
s s / s s	s s / s s	s s / s s	s s / s s	40	
s s / s s	s s / s s	s s / s s	s s / s s	60	
— — / s s	— — / s s	— — / s s	— — / s s	100	
— — / — —	— — / — —	— — / — —	— — / — —	150	
+ + / + +	+ + / + +	+ + / + +	+ + / + +	0	
+ + / + +	+ + / + +	+ + / + +	+ + / + +	0	
+ + / + +	+ + / + +	+ + / + +	+ + / + +	0	

All drops were inoculated into bouillon jars on the 7th day; all were found to be pure cultures of Prodigiosus, and all remained sterile

Series 35. (20/8. 99.)

No.	Tr.	A.	V.	Sec.	16 hrs.	3 T.
1	30°	—	—	0	+ +	+ +
2	„	35	51—54	60	+ +	+ +
3	„	„	51—53	120	+ +	+ +
4	„	„	52—53	180	+ +	+ +
5	„	„	50—53	240	+ +	+ +
6	„	„	51—54	300	+ +	+ +
7	30°	—	—	0	+ +	+ +
8	„	35	50—53	60	+ +	+ +
9	„	„	51—52	120	+ +	+ +
10	„	„	50—53	180	+ +	+ +
11	„	„	51—54	240	+ +	+ +
12	„	„	50—53	300	+ +	+ +

As a control experiment to see whether the quality of the broth changed by the illumination played a role in the previous series of experiments, four sterile broth drops were placed on each of the cover quartz crystals 1-12, after which the illumination was carried out as usual. Immediately after illumination, all drops were inoculated: Nos. 1-5 from a 24-hour-old Prodigiosus culture, Nos. 7-12 from a 4-hour-old one. After 16 hours, all drops of Prodigiosus were level and strongly turbid. Inoculation was carried out with the tip of a 0.2 mm thick platinum wire without an eyelet so that large quantities of the exposed, unilluminated broth were not transferred simultaneously with the inoculation.

It can be seen from this experiment that the light intensity used in the present experiments did not noticeably change the properties of the broth as a nutrient medium at the times in question.

Series 36. (25/5. 99.) (continued on pp. 76-77.)

No	Tr.	A.	V.	Sec.	1 T.	3 T.	4 T.	15 T.	Sec.	
1	15°	35	50	30	— —	S —	— +	— +	30	15° After 4 Stunden.
2	„	„	50—51	50	— —	S —	— +	— +	50	
3	„	„	50—51	70	— —	S —	— +	— +	70	
4	„	„	50—52	100	— —	— —	— —	— —	100	
5	„	„	50—52	130	— —	— —	— —	— —	130	
6	30°	35	50	30	— —	S S	+ +	+ +	30	30° After 4.20 Stunden.
7	„	„	50—52	50	— —	— —	— —	— —	50	
8	„	„	50—51	70	— —	— —	— —	— —	70	
9	„	„	50—52	100	— —	— —	— —	— —	100	
10	„	„	50—52	130	— —	— —	— —	— —	130	
11	45°	35	50	20	— —	S —	— —	— —	20	45° After 4.40 Stunden.
12	„	„	50—52	40	— —	— —	— —	— —	40	
13	„	„	50—51	60	— —	— —	— —	— —	60	
14	„	„	50—52	80	— —	— —	— —	— —	80	
15	„	„	50—52	100	— —	— —	— —	— —	100	
16	„	„	50—52	130	— —	— —	— —	— —	160	

Series 35. (20/8. 99.)

No.	Tr.	A.	V.	Sec.	16 hrs.	3 T.
1	30°	—	—	0	+ +	+ +
2	„	35	51—54	60	+ +	+ +
3	„	„	51—53	120	+ +	+ +
4	„	„	52—53	180	+ +	+ +
5	„	„	50—53	240	+ +	+ +
6	„	„	51—54	300	+ +	+ +
7	30°	—	—	0	+ +	+ +
8	„	35	50—53	60	+ +	+ +
9	„	„	51—52	120	+ +	+ +
10	„	„	50—53	180	+ +	+ +
11	„	„	51—54	240	+ +	+ +
12	„	„	50—53	300	+ +	+ +

As a control experiment to see whether the quality of the broth changed by the illumination played a role in the previous series of experiments, four sterile broth drops were placed on each of the cover quartz crystals 1-12, after which the illumination was carried out as usual. Immediately after illumination, all drops were inoculated: Nos. 1-5 from a 24-hour-old Prodigiosus culture, Nos. 7-12 from a 4-hour-old one. After 16 hours, all drops of Prodigiosus were level and strongly turbid. Inoculation was carried out with the tip of a 0.2 mm thick platinum wire without an eyelet so that large quantities of the, unilluminated broth were not transferred simultaneously with the inoculation.

It can be seen from this experiment that the light intensity used in the present experiments did not noticeably change the properties of the broth as a nutrient medium at the times in question.

Series 36. (25/5. 99.) (continued on pp. 76-77.)

No	Tr.	A.	V.	Sec.	1 T.	2 T.	3 T.	4 T.	15 T.	Sec.	
1	15°	35	50	30	— —	s —	+ +	+ +	+ +	30	15° After 4 Stunden.
2	„	„	50—51	50	— —	s —	+ +	+ +	+ +	50	
3	„	„	50—51	70	— —	— s	— —	— +	— +	70	
4	„	„	50—52	100	— —	— —	— —	— —	— —	100	
5	„	„	50—52	130	— —	— —	— —	— —	— —	130	
6	30°	35	50	30	— —	s s	+ +	+ +	+ +	30	30° After 4.20 Stunden.
7	„	„	50—52	50	— —	— —	— —	— —	— —	50	
8	„	„	50—51	70	— —	— —	— —	— —	— —	70	
9	„	„	50—52	100	— —	— —	— —	— —	— —	100	
10	„	„	50—52	130	— —	— —	— —	— —	— —	130	
11	45°	35	50	20	— —	s —	— —	— —	— —	20	45° After 4.40 Stunden.
12	„	„	50—52	40	— —	— —	— —	— —	— —	40	
13	„	„	50—51	60	— —	— —	— —	— —	— —	60	
14	„	„	50—52	80	— —	— —	— —	— —	— —	80	
15	„	„	50—52	100	— —	— —	— —	— —	— —	100	
16	„	„	50—52	130	— —	— —	— —	— —	— —	160	

The explanation of the experiments.

The first 12 series of experiments are only exploratory, sometimes rather tentative, experiments, as will become clear from the notes appended to each series. In particular, an exact indication of the age of the cultures is missing, and since it has turned out that this moment is of crucial importance, I will omit these first 12 series entirely in the following. The following series are also not all of equal value. In particular, a special position is occupied by the following series

:

Series 14 and 33: The cultures were already attenuated before illumination (see the notes in the experimental protocol).

R. 15 and R. 19: The illumination time was chosen so unfortunate that the killing time was not determined.

R. 25: The culture was contaminated with another microorganism

R. 29: The broth used is 50% thinner than usual, so that the "age" of the bacteria cannot be easily compared with the age of the bacteria in the other series of experiments.

Furthermore, the later series are, of course, on the whole, more reliable than the earlier ones, because I gradually gained more practice and introduced more and more precautionary measures. In particular, the experiments from series 21 onwards must have gained in value because, from this time onwards, I always deposited several, usually four, drops on each covering quartz. For in cases where all four drops gave the same result, the experiment must be considered more reliable than if only one drop had been deposited. And upon closer examination of those cases where part of the four drops was sterilized while the rest showed growth, I became aware of conditions that led me to believe that in one and the same culture

that not all individuals are equally resistant, and in particular that a small number of bacteria can be more resistant to light than the majority of them.

It has been found to be quite constant that, as the illumination time approaches the "absolute killing time" (i.e., the illumination time that definitely kills all individuals in the culture), growth occurs on the same covering quartz only in some of the drops, but not in others. When looking through R. 22-36, it will be difficult to escape the impression that some bacterial individuals in every bacterial culture must be more resistant than the others because they can withstand an illumination time to which their otherwise equal comrades are subject. We further see that the most resistant are in the minority compared to the weaker ones; For in each sterilized drop there were originally hundreds or thousands of bacteria, not a single one of which proved to be resistant, whereas every drop in which growth occurred proves nothing other than that at least one resistant microorganism was present. Higher degrees of resistance are generally found in a number that decreases with increasing for the closer we approach the absolute killing time, resistance; the more consistently it becomes that of the four drops, at most one, shows growth, and where the times have been chosen to be of a suitable length, we see a fairly even increase in the number of sterilized drops on each covering quartz (see, for example, R. 30 to R. 36). We often see that there was not a single living bacillus in the four drops, as all four proved to be sterilized, despite the fact that the absolute killing limit had apparently not yet been reached, as we can see on the next or perhaps

only on the second-nearest covering quartz do we see growth again in a single drop. For example, in R. 23, Nos. 12-22, we saw how, with 20 seconds of illumination, all 4 drops showed growth; at 30 seconds, 3 of 4; at 40 and 50 seconds, 1 of 4; at 60 seconds, 0 of 4; at 70-90 seconds, again 1 of 4; at 100 seconds and above, 0 of a total of 12 drops. If a sufficient number of drops had been deposited in No. 15 (60 seconds), growth would probably have been seen in a certain number of them. The same can be said, but with far less probability, of Nos. 20-22 (100 seconds and more). Therefore, it is necessary to have an overview of the entire series before one can judge to what extent the sterility of all four drops indicates that the safe kill limit has been reached. Of course, the probability that the latter is the case is much greater if the previous numbers have already shown an increasing number of sterile drops. For this reason, in numbers 13-20, where only one drop has been deposited on each cover quartz, the kill limit cannot be determined with as much accuracy as in the later series. If, for example, No. 15 in number 16 is sterilized, this is obviously analogous to, for example, No. 3 in number 22 having three sterile drops out of four. The kill limit in R. 16 is evidently somewhere between 60 and 120 seconds; even 120 seconds would not be reliable if we had not just seen that numerous individuals had already perished at 20 and 30 seconds (i.e., Nos. 15 and 17). More difficult to interpret are the cases, which are incidentally only few, where, as in R. 22, Nos. 13-24, after a larger number of sterile numbers, growth suddenly appears in a single drop of 4. Whether in this case this means that the kill limit is above 120 seconds, or the number of resistant individuals in this culture was unusually small, or whether Nos. 18 and 22 are to be understood as

"coincidences" that have remained in life, e.g The possible causes, e.g., that some bacteria were shaded by a speck of dust, or due to other experimental errors, cannot be determined from the series itself. However, the interpretation of these becomes less difficult when we see the results of these series alongside those of the other series in a graphic representation (see below). If, for example, For example, if No. 12 in R. 31 shows growth in a single one of four drops, while the two preceding numbers (10 and 11) with a total of eight drops were completely sterilized, and the cultures with an even shorter illumination time (No. 9) already had some sterilized drops, it becomes likely that No. 12 is due to "chance", especially when we also see that in all other series with cultures of corresponding age the kill limit is approximately half the illumination time of that for which No. 12 was exposed (see the graphic representation, Table 1, where No. 12 is marked as a small circle).

My view that only a few individuals in any culture are more resistant than the majority of bacteria is also confirmed by the study of the "scattered" (denoted by s) colonies. Without wishing to go into this interesting phenomenon in more detail for now, I will only report how this form of growth manifests itself in direct observation. While all unlit control drops are diffusely cloudy from the growing culture after approximately eight to ten hours, the scattered growth always appears later (at the earliest, the 15th to 20th hour) and originates from one or more discrete points in the drop. Such a point appears, where I have observed one at the earliest so far, as a cluster of bacteria just visible to the naked eye, stuck directly on the underside of the covering quartz. Microscopically, this cluster consists of

from densely packed masses of bacteria, while no growth is observed anywhere else in the liquid, only a few evenly distributed bacteria, which are evidently the bacteria originally present in the drop but killed by the light; for their number remains unchanged over the following days, while the s-spot grows very quickly into a compact hemisphere up to 1 mm in diameter, with rapid, vivid red pigment formation, which is usually already evident from the 24th hour onwards (while the diffusely growing cultures only acquire a diffuse reddish color quite late, on about the third or fourth day). Only in rarer cases (see experimental protocol) does diffuse growth later occur in the drop around this bacterial colony. In most cases, such an s-colony persists unchanged for days or weeks, and neither macroscopically nor microscopically can one find any signs of growth anywhere in the surrounding broth Generally speaking, one can say that the shorter the illumination time, the more numerous the s of each individual drop. Where all four drops yield s (e.g., R. 36 No. 24), there are usually several, up to ten; where only some of the four drops show growth, only one s is found, rarely a pair in each drop (e.g., R. 36 No. 26); in isolated surviving cultures (such as No. 23 or No. 28 of the same series), there is always only one. This scattered growth, originating from isolated points, the number of which decreases with increasing illumination time, is thus consistent with the circumstance discussed (p. 79) that the number of sterilized drops on each cover quartz increases with illumination time, and can, like this, find the simplest (but of course not the only possible) explanation in the fact that only a few individuals were more resistant than the majority. The possible cause of this individual resistance,

I will discuss in more detail below. The reasons why they grow as a clump and do not grow into the rest of the drop are as yet unknown to me.

I discussed earlier (p. 10) that an actual attenuation has not yet been proven by the commonly used Buchner method, but that what has been interpreted as an attenuation can be explained by the fact that some of the bacteria in the culture in question are killed and only some of them remain alive, without being forced, based on previous experimental results, to assume a reduced vitality of the surviving individuals. On the other hand, I believe that in my series of experiments, an unmistakable attenuation can be observed. When the cultures are examined for the first time after illumination, usually 12-15 hours later, we see that the illuminated drops are almost always still quite clear, whereas the control drops are all already very turbid One will see from the experimental protocol that a culture can only exceptionally tolerate 30 seconds of illumination without its development being retarded; indeed, usually 10 seconds, sometimes even 5 seconds, are sufficient to bring about this result. On the whole, we see an increasing retardation of development with increasing duration of illumination; where such a retardation is not evident in the tables, it is simply because the first burst of growth was not always noted immediately, the results being recorded only at certain times of day (usually morning and evening) for practical reasons. R. 24 shows that if the culture is observed at sufficiently short intervals, a certain proportionality between the illumination time and the retardation of growth becomes clearly apparent. Incidentally, this relationship can also be seen clearly enough, e.g. B. in R. 14 (10-16), 18, 19 (1-23), 20, 21, 23, 25, 27 (7-12), 28, 30, 34, 36 (29-34).

Now, one could perhaps object that this delayed growth of the colonies could be caused by the fact that the majority of the bacteria had been killed, so that only so few bacteria remained alive that they needed longer than usual to populate the drop to such an extent that the growth became visible to the naked eye, or that, in other words, here too there was a reduction in number, i.e., a dilution, but not a weakening. The following should be emphasized:

1. Only a single surviving bacillus, if its vitality was to be unimpaired, had to be able to populate the drop faster than after 50-60 hours (R. 21.6, 24-11, 28.20, 30.27, 14, 35, 36-32) or even on the 4th day (R. 18.9, 23.6, 30.22, 34-6).

2. We have seen how isolated surviving bacteria (namely s,

The "scattered" ones can very well give clearly visible growth quite early (e.g., R. 22 within 19 hours, R. 23, R. 24, and R. 25 within 17 hours, R. 27 within 14 hours), but where they have been illuminated close to the kill limit, they nevertheless often only appear very late (e.g., R. 36, 32, 34-6, 30, 22, and many others).

3. In R. 24, we see how an illumination time of just 1-3 seconds can delay development. It would be artificial to assume that an illumination time of just 1 second would have killed the majority of the drop's inhabitants in a culture where the absolute kill limit is higher than 50 to 60 seconds

4. We often see that both the diffusely growing drops (+) and the scattered ones (s) are delayed. As far as I can see, it would require a very complicated hypothesis to reconcile these four facts without assuming an attenuation of the bacteria.

Incidentally, I am far from proposing the theory of a few resistant individuals in each culture, or the theory of the attenuation of individual bacteria by light, as proven by my experiments. I only propose them as the simplest explanation I have been able to find. Nor do I base the following conclusions on these theories.

Therefore, when I use the word "attenuation" in the following, one need understand nothing other than the fact that the culture in question grew later than the control cultures, and by "dilution" I mean only the fact that only a portion of the drops on the same covering quartz showed growth

I need not go into detail here about what is known about the two conditions discussed, examined by attenuating agents other than light. I will only remind you that it has also been believed that it is possible to detect "exceptional cells" in other ways,

individual individuals that behave differently in certain respects than the majority of bacteria in the culture in question.

The Influence of the Age of the Culture.

Although some earlier investigators have stated the approximate age of the cultures used, I have not been able to find a systematic study in the literature on the influence of age on the resistance of bacteria to light

That the resistance of the Prodigiosus to light increases with the age of the culture is proven by all experiments directed at this point, namely series 13, 14, 18, 20, 21, 27, 28, 29, 30, 34, 36, and nowhere does a conclusive experiment contradict this. Everywhere we see that the absolute killing time (p. 79) is shorter for the younger cultures than for the older ones

Within each of the series mentioned here, the temperature was kept constant; the young and old cultures were illuminated either simultaneously or immediately after each other, often alternately. In general, the old and young cultures within each experimental series were treated exactly the same from beginning to end. The proof is therefore, as far as I can see, conclusive. Incidentally, it is not only the absolute killing time that increases with age; we also see that the "dilution" (p. 84) occurs in accordance with this. It is, so to speak, constant that the dilution in the younger cultures becomes apparent after shorter illumination times than in the older ones, and where the illumination times are fortunately chosen, we see that with illumination that produces a strong dilution in a younger culture, a weaker dilution occurs

thinning conditions in the older cultures (e.g., R. 34, Nos. 5 & 29, Nos. 13 & 37, Nos. 21 & 45, R. 36, Nos. 2 & 19, Nos. 11 & 29).

If one now wants to compare the various series with each other and also include experiments carried out in other respects (e.g., to investigate the influence of heat), one cannot, of course, expect mathematically exact agreement between experiments spread over a period of half a year, during which the experimental technique gradually developed. It must be all the more convincing if, nevertheless, these experiments, placed side by side, produce a reasonably uniform result, so that the smallness of the variations is rather surprising when one considers how capricious the growth conditions of bacteria often are

In order to be able to record the results graphically in an easily understandable form, one must take into account that the killing time for the method used is not specified by a single, specific number, but rather by finding a larger or smaller range within which it must lie. If, for example, in R. 34, No. 13 has fully grown despite 60 seconds of illumination, while Nos. 14 and the following were sterilized with at least 100 seconds of illumination, the killing limit probably lies somewhere between 60 and 100. On the graphic representation, I will indicate such an experiment by a vertical line drawn solid up to 60 and from there dashed to 100. The dashed section then indicates the range, and the killing limit can be imagined anywhere within it; In many cases, if one surveys the series in question as a whole, taking into account the "dilution" and the "attenuation," one can judge quite well at which point

the margin, the probable killing limit, lies. But in order not to introduce a point that appears more or less arbitrary, I have not provided such a curve for the probable killing time. Anyone interested will be able to construct one using the experimental protocol.

On Plate I, I have shown the most complete and uniform

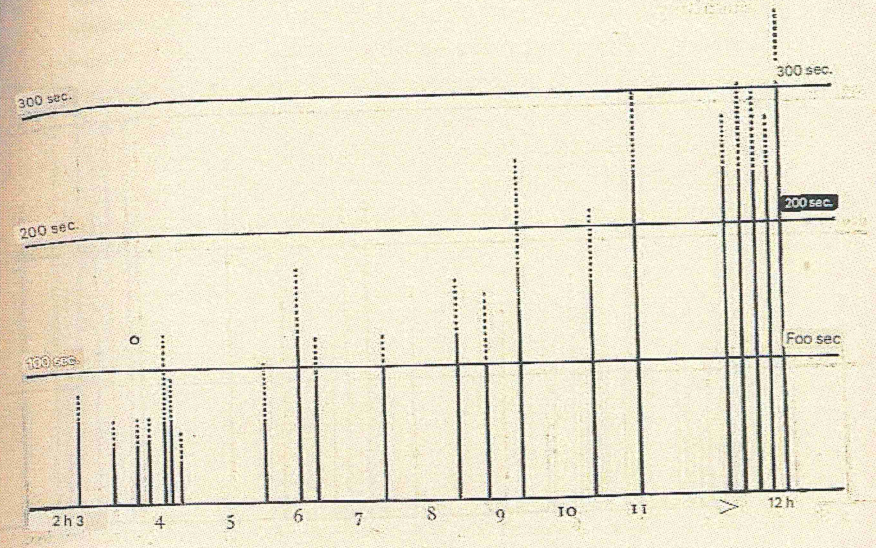

Plate I

The sixth of the series of experiments is shown, namely all those conducted at 300°C and with more than one drop on each cover quartz. I have only excluded R. 29, where a different type of broth is used than for the other experiments (incidentally, the relative values, namely the increase in resistance with age, are the same as in the other series, but the absolute values for each individual age group are slightly different).

One can see how the killing time, which for 3- to 4-hour-old cultures is between approximately 40 and 80 seconds, reaches values between 100 and 120 seconds at the 6th to 7th hour, approaching 200 seconds during the 8th to 11th hour. From the 12th to the 12th hour, this limit is exceeded, and the bacteria are only reliably killed between 250 and 300 seconds; some even survive 300 seconds of illumination.

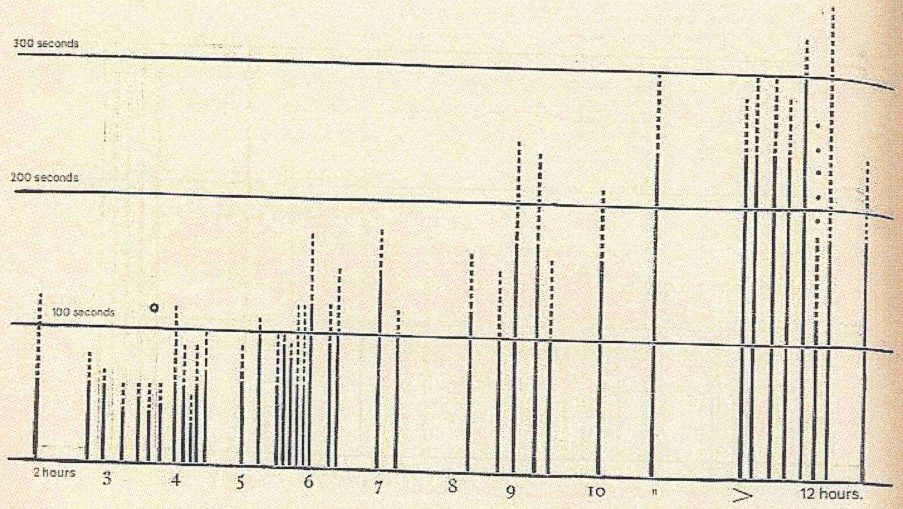

Plate II

In essence, the same picture emerges when I include all the other series where the age is given at all (Plate II), i.e., both the series where the mortality limit is less precisely determined because there was only one drop on each covering quartz, as well as the experiments where temperatures other than 300°C were used (namely, 150, 180, 200, 260, 36°C). However, I did not include the experiments conducted at 450°C; because, although

Although this shows the influence of age in the same way, the absolute values here, precisely because of the temperature (see p. 93), are so deviant that they would only make the interpretation of the image more difficult. I have also excluded R. 14 (see the note on this in the experimental protocol), R. 15, 17, 19, where the killing limit was not reached at all, R. 22 (13-24), where the limit was uncertain, R. 25, where the culture was contaminated, and R. 29, where a different type of broth was used. I have not included R. 16 because it is doubtful what age should be assigned to it (cf. note on R. 16).

We see that the image (Plate II), despite the fact that some not entirely pure cases have been included, has retained the same character: increasing resistance to light with increasing age

Some experiments have indicated that we have already reached a maximum of resistance at an age of approximately 12 hours, with cultures of 2-3 days (R. 13 and 14) and 1-2 months (R. 20) appearing no more resistant than the 1- to 14-hour-old cultures. The 4- to 5-day-old culture in R. 21 survived 300 seconds of illumination. However, we must, of course, await further experiments in this area

The resistance of very young, 1/2-1 hour-old cultures must be investigated as a special question. It has been shown, for example, in Series 21, that if a certain amount of an old broth culture is transferred to sterile broth and then illuminated, which requires at least 1/2 hour for the preparation of the specimens, etc., this mixture still behaves as an "old" culture with regard to killing time. One might therefore perhaps obtain some clarity about how quickly the old bacteria rejuvenate themselves by division if one examined the period between 1/2 hour and 3 hours to see when and how quickly the culture converts its high killing time into a low one. This must be reserved for future investigations.

If one considers the great importance of age for resistance with the two relationships discussed earlier, namely that the number of most resistant individuals is probably relatively small, and that

Increasing degrees of resistance are found on the whole in an ever-decreasing number of individuals the closer one approaches the kill limit, one could perhaps assume that it is the oldest individuals that are the most resistant. If one were to imagine that in a culture there existed at all times a number of individuals who, for some reason or other, did not divide, but assumed a, if you will, "sporoid" state, which became more and more pronounced with age, such individuals would have to appear in a similar way to what I have found characteristic of the most resistant individuals. In one, for example, For example, in a culture 12 hours old, as we have seen, one probably finds not only individuals with maximum resistance (i.e., 250-300 seconds of killing time), but also others, and indeed more numerous, whose killing time is around 200 seconds, others even more numerous around 100 seconds, while the vast majority, just like the younger cultures, are killed in less than 100 seconds. Why very young individuals, say, for example, 1/2 hour old, should be distributed according to such a scale because they were born in an old culture could only be explained by an artificial hypothesis, since they are born under exactly the same conditions. But we would have a relatively simple explanation if we assume the existence of the discussed "sporoid" individuals of different ages with correspondingly different levels of resistance. Such individuals would probably have to be distributed, in terms of number, according to a scale like the one mentioned, since the production of "sporoid" individuals would probably have to be in a certain relationship to the absolute number of individuals of which the culture consisted at a certain point in time.

This is only a suggestion for a hypothesis; should it

find confirmation, it might be worth the effort to investigate whether other types of "exceptional cells" can be interpreted in a similar way.

What this greater resistance of the older cultures is actually based on, I leave to debate until further investigations are available, since the current investigations are only complete insofar as they have discussed some of the most important conditions for obtaining consistent experimental results—which therefore primarily requires consideration of the age of the culture, at least when working with Prodigiosus But whether other bacteria behave in a similar manner, whether chemical changes in the nutrient medium play any role, whether pigment formation is a contributing or perhaps even the sole cause, whether there are truly vital changes in the bacterial bodies or more accessory conditions in the culture, such as the larger number of individuals per unit volume or perhaps simply clumping due to a type of agglutination in older cultures, or finally, a reduced permeability to bacteriocidal rays with age, either of the bacterial bodies or of the nutrient medium, are matters that must be reserved for future investigations. However, my experiments reported here already provide a clue to the solution of some of these questions; I will mention the following, for example: —

Mei1. It is unlikely that a change in the chemical composition of the nutrient medium with the age of the culture is decisive for the resistance acquired with age. For in R. 21, R. 27, and R. 28 (cf. also R. 20, R. 29), only 0.04 cm^3, 0.06 cm^3, and 0.02 cm^3 of the old culture were transferred into 2.0 cm^3 of sterile virgin broth; despite this strong dilution, the cultures illuminated as quickly as possible thereafter behaved like old cultures

2. These same experiments also contradict the idea that a reduced radiance of the nutrient medium with age is decisive.

3. The importance of pigment formation can be demonstrated most clearly through experiments with non-pigmented bacteria. That pigment formation is important for very old cultures with a macroscopically clear pigment layer is beyond question. But we see numerous examples in the series of experiments that resistance is significantly increased at a time when neither macro- nor microscopic pigment can be detected in the cultures; but I cannot, of course, definitively deny from these experiments that some individuals were protected by pigment

4. That the cause could lie in the increasing number of bacteria per unit volume with age, whereby some bacteria overshadow others, is an obvious thought, and if the culture is highly turbid, this will probably actually occur; but based on the following experiments, I do not believe that it was of any importance in my experiments:

In R. 20, we saw that the 1-2 month-old culture, which was so highly diluted with sterile broth that it was clear, was more difficult to kill than the 6-hour-old culture, even though the latter was already turbid.

From R. 21, it can be seen that it does not make much difference whether one has 1 or 25 bacteria per unit volume.

In R. 27, 28, 29, the old cultures were so highly diluted that they were clear, while the younger cultures were turbid; nevertheless, the latter were killed more quickly than the former

5. It would be an obvious idea to attribute some significance to the formation of clumps of bacteria clustered together, which increases with the age of the culture.

for the greater resistance of the old cultures. In cultures more than one day old (R. 13, 14, 20, 21), such clumps are constantly found; in these cases, it is therefore not likely that the clumps may have played a role. But in the experiments where the culture was 3-14 hours old, no clumps were found in the drops sitting on the cover quartz when they were examined microscopically, either immediately after they had been deposited on the cover quartz or the day after illumination. Moreover, the regularity with which both the thinning and the complete sterilization occur speaks against the idea that clump formation was decisive

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Whatever the reason for the resistance of older cultures, it seems to me to be of biological interest that a Prodigiosus culture, over the course of about 10 hours—for example, over the course of one night—achieves such resistance to light that it can endure 5-6 times more light than when it was 3 hours old.

The influence of temperature.

Since several researchers (e.g., d'ARCY and HARDY, DOWNES and BLUNT, DUCLAUX, GAILLARD, KRUSE, LAURENT, MOMONT, RASPE, ROUX, MARSHALL WARD, WESBROOK) have stated that the effect of light on bacteria is based on oxidation, it is obvious to investigate whether the effect of light, like most other oxidation processes, increases with rising temperature. As far as I know, there is no

exhaustive investigations into this. Saverio Santori is said to have found that sunlight is less powerful at lower temperatures than at higher ones. I do not know his work in the original, but since other of his results, as a result of presentations, are in complete contradiction with what we otherwise consider to be established, one cannot attach much importance to his work. Kruse conducted a single series of experiments with typhus broth cultures in test tubes, which he exposed to sunlight in shallow dishes containing water at approximately 0°C, approximately 16°C, and approximately 35°C. He believes he can conclude from this experiment that the effect of sunlight increases with temperature. But, apart from the errors generally inherent in test-tube experiments (p. 7) and the small number of experiments, the results themselves do not seem very convincing to me He found, by counting the colonies, that at 0°C, 2 hours of illumination were necessary to achieve the same degree of "attenuation" that was achieved at 16°C by 1 hour of illumination and at 35°C by 2 hours of illumination. According to this, one would believe that the effect at 35°C was weaker than at 16°C. Kruse, however, thinks the opposite. He considers the light effect at 35°C to be stronger than that at 16°C because the culture initially grew more strongly at 35°C than at the other temperatures and was therefore later "attenuated." This latter reasoning is correct enough in itself, but the first conclusion is not compelling. One can admit that these experiments do not contradict a stronger light effect at higher temperatures, but the experiments (at least for the temperature 35°C) do not contain any evidence for such an assumption.

My own experiments on the influence of temperature (besides the fact that I always maintained a constant temperature in the

individual series of experiments) are carried out in such a way that drops taken from one and the same culture were exposed to light at different temperatures of the water surrounding the preparations. I carried out the following such experiments:

Series 15 and Series 17, where no result was obtained because the killing limit was not reached.

Series 16 shows no noticeable difference between 200 and 300, but the series of experiments were so unfortunate that a large lacuna was present at the crucial point (between 60 and 120 seconds).

R. 22 is not conclusive with regard to the killing time, because the assessment depends entirely on whether one wishes to regard No. 22 as a "chance" or not. But the "dilution" is much greater at 35° than at 150°

R. 23 gives the killing time for 180 between 100 and 110 seconds, while for 360 it is between 90 and 100 seconds. The difference is only small, but it is increased by the fact that both the attenuation and the "dilution" are more pronounced at 360 than at 180. And although the culture, when illuminated at 36°C, had become half an hour older than the drops illuminated at 18°C and consequently, as we saw, must have become more resistant, it was nevertheless killed more quickly. Finally, the result is supported by the fact that

R. 24 gives a very similar picture, with the only difference that, while the cultures of R. 235 were 54 hours old, the culture here

Sib at 16.3 hours and is killed at 60-70 seconds. 36031/2"

„ „ „ „ 50-60 „ indi

Incidentally, the same reasoning applies here as for R. 23.

Photo R. 25, on the other hand, shows a completely opposite picture; but since the culture was infected with a foreign bacterium, one probably shouldn't put much stock in this series

R. 31 compares the effect at 45° with that at 30°. Even if we disregard No. 12, which is possibly a "coincidence," we still get a faster effect at 45° than at 30°.

At 45°, the limit is between 20 and 40 seconds. 300 40 Furthermore,

„ the „ „ „ „ „ „ 60 „

is much greater at 45° than at 30°, and while the growth at 30° is diffuse (+), at 45° it is "scattered" (s) (cf. p. 81).

R. 32 gives completely corresponding results:

At 45°C, the limit is between 20 and 40 seconds. 300

150 40 60 „ „ „ „ 90 „ too, „

„ 60 „ „ „ „ Here,

greatest at 45°C.

R. 34 simultaneously examines a 5-6 hour old and an 8-9 hour old culture at different temperatures.

5-6 hour old culture:

At 45°C, the limit is between 40 and 60 seconds. 300

„ 150 „ „ „ „ hour „ 60

„ 60 „ „ „ old and

culture: 100 150 At 45°C, the

100 seconds.

100 „ „ „ „ 150 „ „

100 „ „ „ „ 150 „

Here, too, we see the dilution occurring earlier and more strongly the higher the temperature.

Since in the last three series of experiments, which, incidentally, are the ones just discussed that were carried out with the greatest precautions, one always began with the highest temperature and examined the lowest last, one could theoretically object that if the bacteria illuminated last in each series were the most resistant, this circumstance could be

due to the fact that they had aged about an hour while the first ones were illuminated; in other words, that the result was a consequence of age and not of temperature. Although a comparison with the corresponding ages in Plates I and II (pp. 87-88) will immediately convince one that, in any case, the effect of 450 cannot be explained in this way, I have nevertheless carried out some direct experiments to investigate the justification of this objection, namely:

R. 36, where the experiments at the low temperature were carried out before those at the high temperature. It turned out that the kill limit for one culture at 15°C (4 hours old) was between 70 and 100 seconds. 300 450 4-20 " " 4.40 " and 30 20 50 40

„ 17 The „ two „ „ 30°C „

„ last intervals (20-40 and „ but „ all „ „

drops gave growth after 30 seconds, whereas at 45°C 3 out of 4 drops were sterilized after 20 seconds

For the second culture, the kill limit was 150 (age 9 h) 300 450 > 170 sec. > between

„ 170 „ the 80-100 sec. „

„ 9.40, „ 9-20 19 In this series of experiments, dilution was also stronger at 450.

According to these experimental results, there can be no doubt that Prodigiosus is killed more quickly by light at 450 than at 300, and as a result of Rs. 23 and 24, it is likely that it is killed more quickly at 350 than at 16-180. Whether, however, there is a difference between illumination at 300 and 150 remains doubtful. Series 32, 34, and 36 do indeed speak in favor of a greater effect at 30° than at 15°, but when compiling the remaining figures, Medical Light Institute, II. 7

series of experiments, the picture is so blurred that one cannot yet make a definite statement about it. For example, after these experiments, one cannot rule out the possibility that there is an "optimum" lying somewhere between 150 and 300.

This influence of temperature is of interest from two different points of view. First, from a biological point of view. As the control experiments (R. 35) unanimously state, Prodigiosus suffers no visible damage when exposed to a temperature of 450 for as short a time as my experiments lasted; nevertheless, it is killed more quickly by light at this temperature. Whether increased oxidation is to blame for this, I do not know at present

Secondly, these relationships could possibly have practical significance. Should later experiments show that pathogenic bacteria behave in a similar way, one would have to ensure during light therapy that the affected area of skin is not cooled more than necessary so that the patient is not bothered by the heat rays.

Although I do not expect other researchers to find exactly the same absolute values as I did in the above experiments, because so many other, partly still unknown factors in the living conditions of the bacteria.
can become important, I nevertheless believe that it is not without significance to be able to establish certain numerical data that apply under specific conditions. I have thus found that under the influence of light located 28 cm from an electric arc of 35 amperes and 50 volts, at an angle of 450 with the axis of the carbons, after a portion of the heat rays has been retained by a 25 mm thick water

layer between quartz plates, and at a temperature of 30°C, a 3-hour-old Prodigiosus broth culture in a hanging drop is sterilized in about one minute, while a 10-15-hour-old culture only takes 3-5 minutes. At 45°C, the light acts faster than at 30°C, so that a 3-hour-old culture is sterilized in about 1/2 minute. Without careful consideration of the age of the culture and the temperature, one cannot expect consistent experimental results, because these two factors together can cause the killing time to be ten times longer in one case than in another.

Copenhagen, November 1899.

Bibliography

on works concerning the effect of light on microorganisms.

(The works whose titles are dotted are known to me only through reports).

d'ARCY U. HARDY. Note on the oxidizing powers of different regions of the spectrum in relation to the bactericidal action of light and air.
Journ. of Physiol. 1894-95, vol. XVII.

ARLOING. Influence of light on vegetation and pathogenic bacteria of Bacillus anthracis.
C. r. t. C, February 1885, p. 378.

— Influence of the sun on the vegetation of the spores of Bacillus anthracis. C. r. t. CI, August 1885, p. 511.

— influence of the sun on vegetation, vegetation, and the the virulence of Bacillus anthracis cultures
C. r. t. CI, August 1885, p. 535.

ARLOING. Influence of the white light and its constituent rays on the development and properties of Bacillus anthracis. Arch. de phys. norm. et path. 1886, t. VII, No. 3, p. 209.

— The spores of Bacillus anthracis are released by the solar light. C. r. t. CIV, Marts 1887, p. 701.

— Correspondance to M. le Director des Annales (Duclaux). Ann, de l'inst, Pasteur, Decbr. 1887, p. 595.

d'ARSONVAL AND CHARRIN. Influence of the atmospheric agents, en particulier de la lumière et du froid on the bacille pyo-cyanique. Sem. médic. 1894, No. 4..

Arch, de phys, norm, et path. t. VI, 1894, p. 335.

DE BARY. Research on the development of quelques champig-nons parasites. Ann, de sc. nat. IV. Botany t. XX, 1863..

BECK AND SCHULTZ. On the effect of so-called monochromatic light on bacterial development. Journal of Hygiene 1896, p. 490.

Beyerinck. On the respiratory patterns of motile bacteria. Centralblatt f. Bakt. XIV, 1893, p. 827.

BIE. Undersøgelser over Virkningen af Spektrets forskellige Af-delinger paa Bacteriers Udvikling. Medd. fra Finsens Lysinstitut I, 1899.

— Om Lysets Evne til at dræbe Gær- og Skimmelsvampe. Medd. fra Finsens Lysinstitut I, 1899.

— Investigations into the bactericidal effects of the various parts of the spectrum. Reports from Finsen's Medical Lys Institute I, 1900.

— On the power of light to kill fungi and molds. Reports from Finsen's Medical Lys Institute I. 1900.

Billings u. Peekham. The influence of certain agents in destroying the vitality of the typhoid and of the colon bacillus. Science News, 1895, I, 7, p. 169.

Bock. On the effect of monochromatic light on bacterial development. Magazine f. Hyg. and Infk. 1896, XXIII, p. 490.

BUCHNER. On the influence of light on bacteria. First Report. Centralblatt f. Bakt. XI, 1892.

— On the influence of light on bacteria. Part II. Centralblatt f. Bakt. 1892, XII.

— On the influence of light on bacteria and on the self-purification of rivers. Arch. f. Hyg. 1893, XVII, p. 179.

CHARRIN. The atmospheric agents and the bacteria. IIème Congr. int. d. med. Rome 1894. Ref. sem. med. 1894, p. 176.

Chemelewsky. On the question of the effect of sunlight and electric light on pus bacteria. Wratsch 20/92. Ref. Centralbl, f. Bakt. 1892.18

CHMILIEWSKY [identical to the previous one]. On the question of the influence of sunlight and electric light on pyogenic microbes. Chir. Wjestnik 12/93. Ref. Centralbl. f. Bact. 1894.

DANDRIEU. Influence de la lumière dans la destruction des bac-téries pour servir à l'étude du all à l'égout". Ann. d'Hyg. 1888, p. 448.

DIEUDONNE, Contributions to the evaluation of the effect of light on bacteria. Arb. a. d. Kaiser. Ges.-Amt. 1894, IX, p. 405. -

Significance of hydrogen peroxide for the bactericidal power of light. Ib.

Downes u. Blunt. Researches on the effect of light upon bacteria and other organisms. Proceed. of the Royal Soc. of Ld. Decb. 1877, vol. XXVI, p. 488.

— On the Influence of light upon protoplasm. Ib. Decb. 1878, vol. XXVIII, p. 199.

Downes. On the action of sunlight on mikroorganisms etc., with a demonstration of the influence of diffused light. Proc. of the R. S. of Ld. Jan. 1886. vol. XL, p. 14. Trans. a. Proceed. of the R. S. of Victoria. Vol. XX.

Duclaux. Influence de la lumière du soleil sur la vitalité des germes de microbes. C. r: Jan. 1885, t. C, p. 119.

Duclaux. On the lifespan of microbes.
Ann. de chim. et de phys. May 1885, series VI, vol. V, pp. 54-59.
— Influence of sunlight on vegetation and the pathogenic properties of Bacillus anthracis.
C. r. t. C. June 1885.
— Influence of sunlight on the vitality of micrococcus. C. r. t. C., August 1885.
— Action of light on microbes, critical review.
Ann. de l'inst. Pasteur. 1887, p. 88
— On the analogies between fermentation and solar combustion processes.
Ann. d. l'inst. Pasteur, 1893, p. 751.
ELFUING. Studies on the effect of light on fungi.
Helsinki 1890.
ENGELMANN. On the light and color perception of the lowest organisms.
Arch. f. d. ges. Physiol. XXIX, 1882, p. 387.
— Bacterium photometricum: a contribution to the comparative physiology of the sense of light and color.
Pflügers Arch. f. Physiol. XXX, 1883, p. 95.
— The purple bacteria and their relationship to light.
Bot. Zeit. 1888, nos. 42-45.
ESMARCH. On solar disinfection
Zeit. f. Hyg. u. Infk. XVI, 1894, p. 257.
SERRANO FATIGATI. Influence of various colors on the development and respiration of influenzae.
C. r. LXXXIX, p. 595.
FAVITZKY. . . . . Wratsch 1890, No. 37.
FERMI U. CELLI. Contribution to the knowledge of tetanus poison.
Centr. f. Bakt. XII, 1892, p. 617.
FINSEN. Om Anvendelsen i Medicinen af koncentrerede kemiske Lysstraaler. Kbh. 1896.
— On the application of concentrated chemical light rays in medicine.
Leipzig 1899
FLÜGGE. Die Mikroorganismen, 1896, I, pp. 88, 136, 159, 163, 208, 301, 334, 343, 432, 435, 442, 495, 400

FRANKLAND. Bacteriology in Some of Its Relations to Chemical Science.
Centr. f. Bakt., 1894, XV, p. 101.
See also Proceedings, R. S. of Ld., 1893.
GAILLARD. De l'influence de la lumière sur les microorganismes.
Th. de. Lyon, 1888
GALEOTTI, Biological research on some experimental chromogenic bacteria, Mem. of origin. 1892.
GEISLER. On the question of the effect of light on bacteria. Centr. f. Bakt. u. P. 1892 Nos. 6-7, XI.
Arch. de méd. exp. et d'anat. path. 1891, F. III, p. 800.
GIUNDI. On the effect of light on acetatic fermentation,
Staz. sperim. agr. ital. XVIII. 1890, p. 171.
GLADSTONE U. TRIBE. . . . . .
Journal. chem. Soc. Aug. 1883.
GREEN. The influence of light on diastase.
Ann. of Boston 1894.
Ref. Centr. f. Bakt
JAMIESON. The influence of light on the development of bacteria.
Nature, July 1882, XXVI, p. 244.
— The influence of light on bacteria.
Trans. a. Proceed. of the R. S. of Victoria, vol. XX.
JANOWSKI. On the biology of typhus bacilli.
Centr. f. Bakt. VIII, 1890, p. 167.
KLEBS. Allg. Path. Jena 1887, vol. I.
KNY. The relationship of light to cell division in Saccharomyces cerevisiæ. Ber. d. deutsch. bot. Ges. II, 1884.
KOCH. Vortr. a. d. 10th intern. Kongr. Berlin, 1890, Verh. vol. I.
KOTLJAR. On the question of the influence of light on bacteria.
Wratsch. 1892
Ref. Centr. f. Bakt. 1892, XII, p. 836.
KRUSE. On the hygienic significance of light. Zeit. f. Hyg. XIX, 1895, p. 313.
AXEL L. LARSEN. Paavirkes de forskellige Bakterier ens eller forskelligt af Lyset?
Medd. fra Finsens Lysinstitut. I, 1899

AXEL L. LARSEN. Do different species of bacteria have the same resistance to light? Reports from Finsen's Medical Light Institute I, 1900.

LAURENT. Influence of light on cereal charcoal spores.

C. r. de la Soc. royale de Bot. de Belg. t. XXVIII, 1889.

Study on the variability of the red bacille de Kiel.

Ann. de l'inst. Pasteur. 1890, No. 8.

LEDOUX-LEBARD. Action of light on the diphtheria bacilli.

Arch. d. med. exp. et d'anat. path. 1893, p. 779

— Action of light on the diphtheria bacilli. Rev. des malad. de l'enfance. 1894, XII, p. 66.

Loew. On the behavior of lower fungi toward inorganic nitrogen compounds. Biol. Centralbl. X. 1890, p. 14.

Lübbert. Biological investigations of split fungi.

Würzburg 1886.

Martinaud. Influence of solar radiation on yeasts that meet on the surface of raisins. C. r. CXIII, 1891.

Masella. Influenza of solar light directly on infections in the caviar containing bacilli of Asian cholera and ileostomy.

Ann. d'Hgiene sperim. V, 1895

Ref. Centralbl. f. Bakt. XVIII, 1895, p. 759.

MIGNECO. Action of solar light on the virulence of the tubercle bacilli.

Annali d'Hgiene sperim. 1895.

— Effect of sunlight on the virulence of tubercle bacilli.

Arch. f. Hyg. XXV, 1895; p. 361.

MOMONT. Action of dessication, of air and light on filamentous bacterium.

Ann. d. l'inst. Pasteur, 1892, p. 21.

MUTSCHLER . . . . .

Research reports on life sciences and their relationship to hygiene, III,

1896. NOCARD. . . . . Veterinary Medical Report, 1885.

ONIMUS. Action on light on microbes.

Th. de Paris, 1889.

PALERMO. Action of solar light on the virulence of the cholera bacillus.

Ann. dell'ist. d'igiene spermim, dell'univ. di Roma, 1893, f. IV. Ref. Centralbl. f. Bakt. XVIII, 1895, p. 665.

PANSINI. Action of solar light on microorganisms. Boll. d. Soc. di naturalisti in Napoli, 1890

PATELLA. Battery research on cruposa pneumonite. Ann. dell'ist. d'igiene sper. di Roma, vol. I, f. I.

PIAZZA. On solar influenza on diphtheria. Ann. d'Igiene sper. vol. V, f. 4.

PALMIRSKI u. ORLOWSKI. . . . . Medycyna, 1895.

PROVE. Le Micrococcus ochroleucus.

Ann. de l'inst. Pasteur, 1888, p. 101.

Cohn's Beitr. z. biol. d. Pflanzen, IV, 3, p. 409.

RANSOME U. DELEPINE. On the influence of certain natural agents on the virulence of the Tubercle bacillus,

Proc. of the Royal Soc. of Ld. 1894, LVI, p. 51.

Raspe. Influence of sunlight on microbes, Inaug. Diss. Rostock.

1891.

Raum. The current state of our knowledge of the influence of light on bacteria and on the animal organism. Zeit. f. Hyg. Vol. VI, 1889.

Richardson. The action of light in preventing putrefactive decomposition and in inducing the formation of hydrogen peroxide in organic liquids.

Journal of Chem. Soc. I, 1893.

Ref. Berichte d. deutsch. chem. Ges., 1893, p. 823.

Roux. On the action of light and air on the spores of Charbon's bacteria

VIX 1681 Ann. de l'inst. Pasteur, I, 1887, p. 174. SANFELICE.

Influenza of the chemical and physical agents based on anaerobic pathogens of the earth.

Ann. dell'ist. d'igiene di Roma, 1893, vol. 4, p. 333.

SANTORINI. Influenza of temperature due to microbial action of light.

Pistos Bollet. d. Acc. med. di Roma 1890. SAVERIO

SANTORI. . . . . .

willing to t o Ann. dell'istit. d'igiene di Roma, II, f. 2. M.

SCHLÖSING U. MÜNTZ. Sur la nitrification par des ferments organisés. C. r: LXXXV, 1877

SCHRÖTER. On some pigments formed by bacteria.
Cohn's Contribution to Biol. of Plants 1872, p. III.
SCHULTZ. On the effect of monochromatic light on bacterial development.
Arch. of Anatomy and Physics I-2, p. 150.
Zeit of Hygienists XXIII, 1896, Physiological Department.
SOYKA. On the influence of the soil on the decomposition of organic substances. Zeit of Biol. XIV, 1878, p. 466.
. . . . . Practitioner, 1893, vol. 50, no. 297. STERNBERG.
STRAUSS. On the action of luminous rays on microbes
Soc. d. Biol. 1886. Ref. Sem. méd. 1886, p. 456.
v. TAPPEINER. On the effect of fluorescent substances on infusoria, based on experiments by O. RAAB.
Vers. d. Ges. deutch. Naturf. u. Ärzte, Munich. Sept. 1899.
Ref. Deutsche med. Wochenschrift No. 42, 1899.
VAN TIEGHEM, Action de la luminère sur la végétation du Penicillium glaucum dans l'oil.
Bull. d. l. Soc. bot. d. France. 1887.
— Culture et développement du Pyronema confluens.
Ib. 1884
TIZZONI U. CANTANI. On the resistance of tetanus bacilli to physical and chemical influences.
Arch. f. exp. Path. XXVIII, 1891.
TYNDALL. Note on the influence exercised by light on organic infusions. Proc. of the R. S. of Ld. Dccb. 1878, XXVIII, p. 212.
— On the arrest of infusorial life.
Nature, Sept. 1881, XXIV, p. 466.
UFFELMANN. Hygienic significance of sunlight.
Wiener Klinik, 1889.
— The self-purification of rivers with special reference to city cleaning. Berl. kl. Woch. 1892.
VAILLARD U. VINCENT. Sur le poison tétanique.
Soc. de Biol., Ref. Sem, med. No. 511, 1890
MARSHALL WARD. Experiments on the action of light on Bacillus anthracis.
Proceedings of the Royal Society of London. 1893, LII, p. 393.

MARSHALL WARD. Further experiments on the action of light on Bacillus anthracis. Ib. 1894, LIII, p. 23. The
— action of light on bacteria. III.
Ib. 1894, LIV, p. 472.
— Further experiments on the action of light on Bacillus anthracis and on the bacteria of the Thames. Ib. 1884, LVI, p. 315.
MARSHALL WARD U., FRANKLAND. First report of the water research committee etc. Ib. 1892, L1, p. 183. Chem. News,
WARRINGTON . . . . . December 1887.
WESBROOK. Some of the effects of sunlight on tetanus cultures. Journal of Pathology and Bacteria, vol. III, p. 70, 1894-95. The
— growth of cholera (and other) bacilli in direct sunlight. Journal of Pathology, III, 1896, p. 352.
WETTSTEIN. . . . . Sitzber. d. Wien. Ak. d. Wiss, 1891.
WINTER. Heliotropism in Peziza fucheliana de By.
Bot. Zeit. 1874.
WITTLIN. On the effect of solar rays on the germ content of street dust. Vienna, Klin, Week, 1806

II. The Actinoscope by Absalon Larsen.

The light-collecting apparatus of the Light Institute is known to be equipped with rock-crystal lenses and combined with a layer of water that absorbs heat rays

The institute has now given me the task of constructing an apparatus with which it can be easily and quickly determined whether the light concentrated by the collecting apparatus contains ultraviolet rays, or whether these have been absorbed, which should not be the case with good apparatus. I have called the apparatus constructed for this purpose the actinoscope. The basis of the apparatus is the phenomenon observed by Hertz that ultraviolet rays promote the generation of electrical sparks. For example, if sparks are formed between a platinum plate and a small brass sphere using a small Ruhmkorff inductor, then the electrodes can be separated significantly further from each other without the sparks ceasing when the platinum plate serving as the negative electrode is irradiated by ultraviolet rays than when this is not the case.

A dry cell and a Ruhmkorff inductor are located in a wooden box (24 × 26 × 26 cm). The

Electrodes are located in a small wooden box (8 × 8 × 17 cm) (Fig. 1). Electrodes a and b are connected to the secondary windings of the inductor by means of well-insulated wires. For convenience, the main current is conducted through an interrupter (not shown in the figure) attached to the small box. The negative electrode a consists of a 2 cm diameter platinum-plated brass plate. The positive electrode is a brass rod b, which can be moved away from or closer to the platinum-plated plate by means of a hard rubber screw head e. The light enters through the opening O and strikes the platinum-plated plate

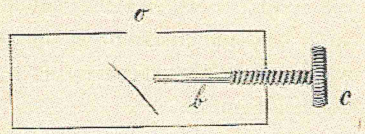


Fig. 5.

The experiment is carried out as follows: The small box is held in the hand so that the platinum plate is in shadow. The main current is closed, and the brass rod is first brought close enough to the platinum plate to produce sparks, and then turned back slightly so that the sparks cease. The box is then held so that the rays to be examined, coming from the collecting apparatus, strike the platinum plate through the opening. If ultraviolet rays are present, lively sparks will immediately arise, which will cease just as quickly if the platinum plate is placed in shadow, or if even a very thin glass plate is held in front of the opening. For control purposes, one checks whether the unconcentrated rays coming directly from the arc lamp can produce sparks.

It is never difficult to decide whether the rays are effective or not. The sound of the sparks is very definite if ultraviolet rays are present. The whole process proceeds

so easy and so fast that 10 collecting apparatus can be tested with the actinoscope in less than 10 minutes.

The institute's collecting apparatus were tested with the actinoscope. Any defects present mostly resulted from contamination in the water layer. In two cases, it was found that the hydrochloric acid used to clean the collecting apparatus had not been rinsed away with sufficient care. In other cases, the contamination absorbing the ultraviolet rays came from the putty used to attach the lenses. In all cases, the apparatus were put back in working order after being rinsed and filled with fresh distilled water. Ordinary water absorbs the rays acting on the actinoscope

As can be seen, the actinoscope can be useful in some cases, although it only provides qualitative and not quantitative results. The rays acting on the actinoscope are located quite far in the ultraviolet region, as can be seen from the fact that they are absorbed not only by glass, but also by very dilute hydrochloric acid, by insignificant inorganic impurities, and by ordinary water.

Since virtually all substances that absorb ultraviolet rays, in small quantities, only cut off the rays furthest in the ultraviolet spectral region and only in larger quantities also absorb the rays closer to the visible spectrum, the actinoscope test can be regarded as a strict test. If the rays act on the actinoscope, one can safely assume that the collecting apparatus is in order with regard to absorption.

Regarding the phenomenon discovered by Hertz, which is put to practical use here, reference should be made to the comprehensive

Investigations by Wiedemann and Ebert[1]) are referred to. From these it follows that the phenomenon is complex and varied, depending on the shape and nature of the electrodes and the type and pressure of the air. In particular, it should be noted that irradiation not only increases the spark length, but also completely changes the character of the discharge.

While working with the actinoscope, I noticed a special circumstance which, to my knowledge, had not been observed before. It turns out that, due to the action of the direct rays of an arc lamp, the discharge occurs most vividly at a certain distance from the lamp, while it ceases both when the apparatus is moved far away from the lamp and when it is brought very close to it

In the latter case, the sparks reappear, either when a screen with a small opening or a layer of water is held in front of the lamp. Light concentrated by a rock-crystal lens onto the platinum plate, on the other hand, had a very strong effect. However, at the time this communication was being written, I have not had the opportunity to investigate this phenomenon more closely.

It should also be noted that the effect of ultraviolet rays on electrical discharges has recently been used for telegraphy.

1) Annalen der Physik und Chemie 33, p. 241 and 35, p. 209, 1888. 2) Elektrotechnische Zeitschrift 19, pp. 414, 481, 826, 1898

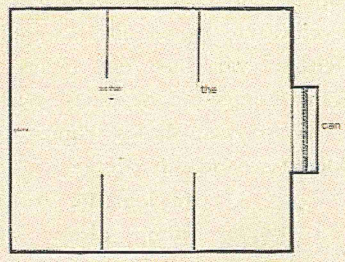
III.

A photometer. By Absalon Larsen.

To measure the intensity of concentrated light, I have constructed the apparatus described below

Some broken rock crystal lenses were crushed into fine sand, which was then suspended in water. What remained suspended after a few minutes was dried and then formed a very fine white powder. This powder was pressed between two rock crystal plates set in a brass ring. The whole now formed a milk-colored plate, which was attached via a round opening to one side of a square wooden box, matte black on the inside and provided with blinds, shown in Fig. 1. a is the milk-colored rock crystal plate, b, b are two blinds with openings the same size as the plate. On the side of the box opposite the plate, which can be opened, a freshly prepared piece of silver chloride paper is attached. Plate a, provisionally closed with a lid (not shown in the figure), is placed where the light is concentrated, and the lid is removed. After

After a certain time, measured with a chronograph, approximately 3 minutes, the lid is placed back over the opening. The silver chloride paper is then blackened, and from the degree of blackening of the paper, the intensity of the light can be determined, as described below. By using the rock crystal plate described, the light is attenuated to such an extent that the time required to produce a suitable blackness becomes so long that it can be measured accurately, whereas with direct irradiation with concentrated light, the paper is blackened in a very short time. On the other hand, the attenuation of the light is not associated with absorption of ultraviolet radiation, which would be the case if an ordinary frosted glass plate had been used. The effect of the fine rock crystal powder on light must be understood as follows: the rays striking the powder, after numerous reflections and refractions, leave the powder again as diffused light in all directions,



be

regarded as a new light source The presence of ultraviolet rays in the diffuse light emanating from the rock-crystal plate under the circumstances mentioned has been confirmed using the actinoscope described above.

The use of photographic paper to measure the chemical intensity of light is a very common procedure, employed, for example, by Roscoe and Wiesner (see Mitteilungen des Instituts I, p. 109, 1900). The aforementioned researchers compared the color of the surface with

of the paper with suitable standard colors. However, there is no simple relationship between the surface color and the amount of light. Therefore, preliminary experiments must determine which amount of light corresponds to each of the standard colors, and afterwards, one must always ensure that the blackening of the paper is equal to that of a standard color, since the eye is not capable of quantitatively estimating color differences. I have therefore dispensed with the use of standard colors and, following Dr. Bang's advice, devised a new method that consists of observing the blackened paper in continuous light. Imagine a piece of exposed paper whose degree of blackening is to be determined.

this paper is placed close to an unexposed piece of the same type of paper, and if the two pieces are exposed to the same intensity at the back in a darkroom, with a light intensity of 1, then, viewed from the front, they will not appear equally bright In Figure 7, a represents the unblackened paper and b the blackened paper. By amplifying the light falling on the back of paper b, it can be achieved that b appears as bright as a. If the necessary light intensity is, for example, 4, while paper a is exposed as before with light intensity I, then I will set the degree of blackening of paper b equal to 3; for if paper b had not been blackened, then light intensity I would be sufficient to make b appear as bright as a; now light intensity 4 is necessary for this; light intensity 3 has then been retained by the silver particles deposited in the paper. Experiments have shown that the degree of blackening determined in this way is at least up to a degree of blackening 2 with

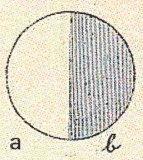


Fig. 7. If

is proportional to the amount of light that caused the blackening. It is therefore more rational to observe the paper in continuous light than to judge the surface color, and the difficult use of standard colors can be dispensed with.

The measurements are carried out with the apparatus shown in Figure 8. C is a double prism according to Lummer and Brodhun 1), D is a magnifying glass. The double prism is ground in such a way that one can look through a certain section of the contact surface of the two halves and thus observe the piece of paper a, while at all other points of the contact surface total reflection occurs, so that one sees the piece of paper b there. a and b are illuminated with two incandescent lamps A and B, which can be moved on two rails provided with graduations. Since one cannot assume that the two incandescent lamps have exactly the same luminous intensity, the experiment is carried out as follows B is placed at a certain distance, e.g., 100 cm, from the unblackened piece of paper b, and A is shifted until the two fields seen in the prism appear equally bright. Now, the blackened piece of paper to be measured is inserted in place of b. To restore equality of the D

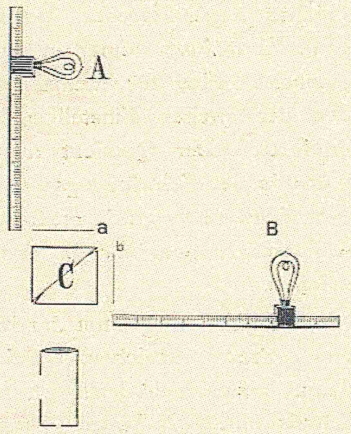


Fig. 8.

1) Zeitschrift für Instrumentenkunde 1892, page 41.

To achieve two fields, one must move B closer to the prism, say to a distance of 50 cm. The luminous intensity of the light falling on b is now 1002 = four times 50 greater than $\left(\frac{\text{before;}}{\text{of}}\right)$ the degree blackening is therefore 3. The luminous intensity of incandescent lamps varies considerably with the operating voltage. This is of no importance, however, if the two lamps are identical and fed from the same line. For convenience, the first adjustment is always made at the same distance. A table calculated for all times then gives the blackening degree corresponding to the second adjustment. The quotient of the exposure time in minutes to the blackening degree gives the luminous intensity. If the blackening degree of several pieces is to be determined, one only needs to make the first adjustment once

With practice, the adjustment can easily achieve an accuracy of 1/2 percent. The difficulty of the method lies in the fact that it is not always easy to have paper of the same sensitivity. However, the same difficulty also applies to the older methods. I have always used Rives raw paper and prepared it myself. Pieces the size of a quarter sheet are placed in a 3 percent NaCl solution for 5 minutes and then hung vertically to dry. After drying, the lower part of the paper, which contains more NaCl than the rest, is cut away. The paper, thus salted, is placed in a 10 percent $AgNO_3$ solution for 3 minutes one day before use and then rinsed three times in pure water for one minute each time, after which it is hung in a darkroom to dry.

The method described here for determining the degree of blackening of photographic paper has been used, among other things, to measure the absorption occurring in agar and broth. Furthermore, the same method has been used to determine the dependence of the photochemical intensity of arc light on the current and voltage, as shown below.

September 14, 1899

IV.

The Dependence of the Electric Arc Light on the Current and Voltage by

Absalon Larsen.

In order to obtain an idea of the nature and magnitude of the changes in the electric arc light associated with changes in current and voltage, I made some measurements of the light intensity, partly with a bolometer and partly with photographic paper. A glass plate was placed in front of the bolometer to absorb heat rays, so that the bolometer measurements approximately indicate the total amount of energy of the visible rays converted into heat, while the measurements with photographic paper, whose degree of blackness was determined in the manner described above, provide an approximate measure of the intensity of the violet rays

The numbers given under "Bolometer" in the following table have been converted so that they indicate how many gram calories per second the rays falling on the bolometer would develop in the bolometer if the bolometer were at a distance of 1 meter from the crater and the surface of the bolometer were one square meter in size. The numbers given under "Photographic Paper" are calculated from the degree of blackening as follows: The degree of blackening,

which in all experiments was between 0.5 and 1, was divided by the exposure time in minutes and multiplied by the square of the distance from the crater expressed in meters. The resulting numbers, which indicate the degree of blackening corresponding to an exposure time of 1 minute and a distance of 1 meter, were then multiplied by 100 so that they could appear as whole numbers

The hand lamp				The shunt lamp			
Ampere	Volt	Bolom.	Photographic Paper	Ampere	Volt	Bolom.	Photographic Paper
7.7	40	7.2	13.3*)	18.5	approx. 50	32.1	62.2
7.6	45	9.3	15.4%	23	„ 50	39.3	125
7.6	50	9.4	15.5	27	50	47.0	98
7.6	55	9.9	15.1%)	30	"50	47.5	165
7.8	60	10.5	15.0%)	35	„ 50	55.8	185
5.3	50	6.9	11.5	39.5	„ 50	61.0	196
6.9	50	9.0	15.2	47.5	„ 50	69.6	324
8.2	50	10.8	24.0	18.5	approx. 50	28	77
11.5	50	14.5	47.2	26.5	„ 50	41	128
13.6	50	17.4	59.2	31.5	„ 50	48	183
7.3	50	9.2	14.2	36.5	„ 50	53	204
8.0	50	11.6	22.7	43.5	„ 50	63	276
10.5	50	14.6	37.0				
12.8	50	17.9	56.1				
15.9	50	21.8	84.1				

I measured the light from a small lamp with manual regulation and carbons of 14 mm and 11 mm diameter and that from a large self-regulating shunt

*) Average of three series of measurements

lamp with carbons of 24 mm and 15 mm diameter. In all experiments, the rays used formed an angle of 450 with the axis of the carbons, and both the bolometer surface and the paper were positioned perpendicular to the rays.

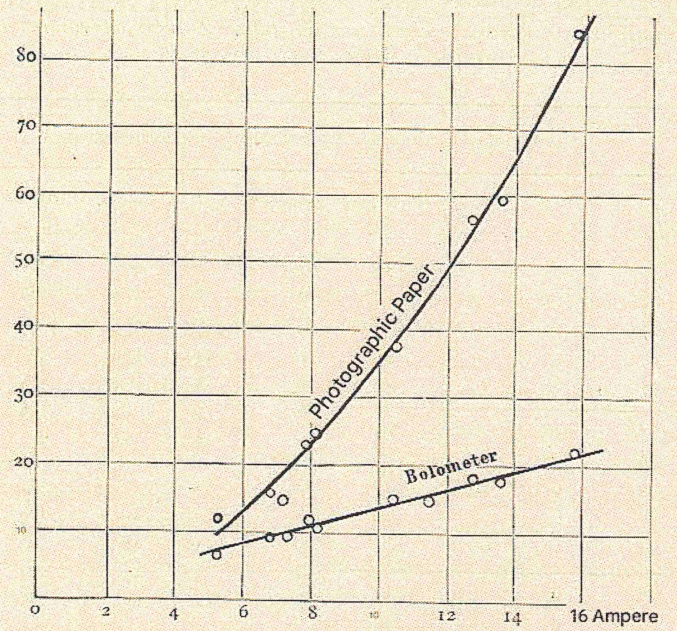


Fig. 9.

The dependence of light intensity on voltage has only been investigated with the hand lamp. At 40 volts, both the thermal effect and the photochemical effect are significantly smaller than at the other voltages. Between 40 and 60 volts, both are to be considered independent of the voltage; but even at a voltage of 60 volts, the lamp no longer burns steadily, and various

experiments at this voltage differ considerably from one another

Two series of experiments were conducted with both lamps at a voltage of 50 volts to determine the dependence of light intensity on current strength. The test results are shown graphically in Figures 1 and 2. The observations are marked by small circles. Curves are inserted between the observations. In Figure 1 (the hand lamp), the deviations between the observations and the curve are generally small, from which one can see that the lamp burned steadily. Larger deviations occur in Figure 2. These arise mainly from the irregularities that arise whenever the regulating device is operating, at least when, as in my experiments, voltage regulation is left to the automatic regulating device alone

The heating effect of the hand lamp is proportional to the current, that of the shunt lamp only approximately. The photochemical intensity, however, increases much faster than the current in both cases. In other words, as the current is increased in a given lamp, the intensity of the violet end of the spectrum increases much faster than that of the red end. For the hand lamp, for example, at 8 amperes, the ratio between the numbers expressing the photochemical intensity and the heating effect is 2, whereas at 16 amperes the ratio is 4. For the large lamp, the ratio is 2.7 at 24 amperes and 5.7 at 48 amperes.

A comparison of the two lamps is best made at currents that are related to the cross-sections of the positive carbons. At 12 amperes, the small lamp gives a heating effect of 16 and a photochemical effect of 49. The large lamp, whose positive

Coal has three times the cross-section, at 36 amperes gives a thermal effect of 56 and a photochemical effect of 198. The ratio of the current intensities is 3, the ratio of the thermal effects is 3.5, and the ratio of the photo-

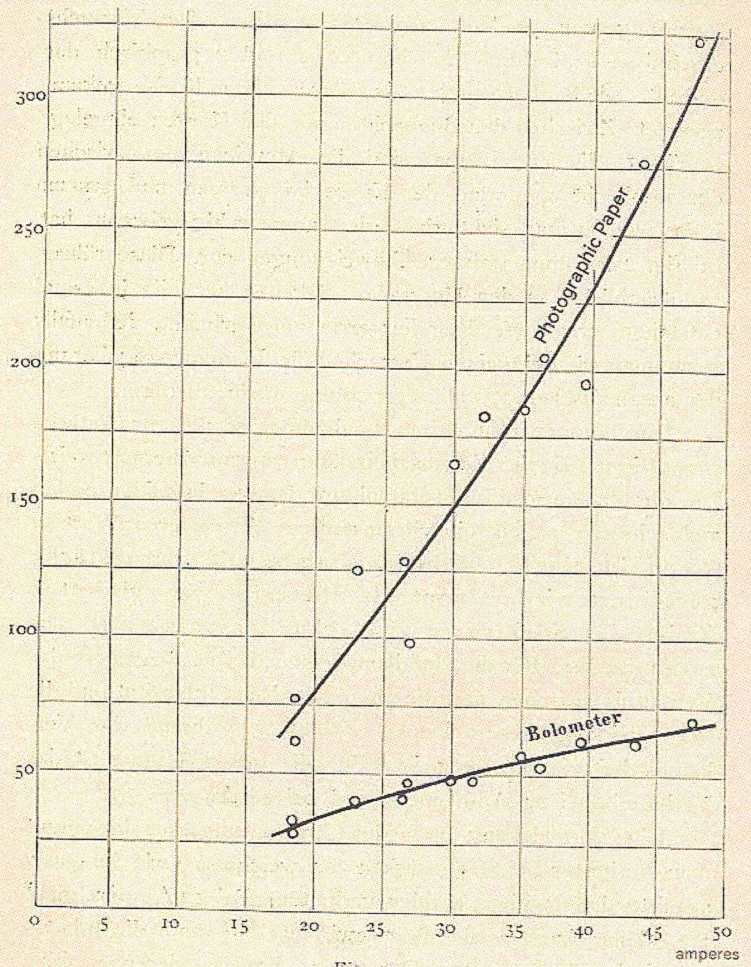


Fig. 10.

chemical effects is 4. Thus, at the same current density, a large lamp is a little more economical than a small one, and the light from a large lamp is a little more developed in the violet spectral region than that from a small one

It is not difficult to see that the results must point in this direction, because an increase in current density and a simultaneous increase in the carbon cross-section must produce a larger crater and a higher temperature, which in turn causes an increased radiation and a shift towards the violet. The experiments reported here can only be regarded as orienting. For an exhaustive investigation, spectral apparatus would be necessary with the help of which the intensity of the radiation could be measured in all spectral regions.

September 27, 1899.

Diakeroioiol The Light as Incitament

by Prof. Dr. Nils R. Finsen.

This treatise is not reproduced in the German edition, as it appeared earlier in Prof. Finsen's book: "On the Significance of the Chemical Rays of Light for Medicine and Biology."

Lupus vulgaris laryngis. A clinical investigation by

Prof. Dr. Holger Mygind

This treatise is not reproduced in the German edition because it appeared earlier in the Archiv für Laryngologie, Vol. X

V.

Report from Finsen's Medical Lys Institute.

From January 1 to December 31, 1899.

The following annual report is of only local interest in many respects, but is reproduced here partly for the sake of completeness, and partly because it provides some clarification on the development of the Light Institute.

I.

By Prof. Dr. Niels R. Finsen.

The institute's first annual report covered the period from August 1896 to December 31, 1897. The current annual report covers the two years from January 1, 1898, to December 31, 1899.

I can begin this annual report, just as I did the previous one, by saying that what we are reporting here is not a quiet, steady activity, but one in continuous and rapid development that is far from at rest

The work of the Institute for the Matter of Light (the demonstration of the application of light in medicine and the efforts towards recognition in the medical world) has grown steadily, and especially in the course of the last year, the practical work, i.e., the treatment of patients, reached a provisional culmination already at the end of 1898, since the limited space did not allow any further increase in the number of patients, so that there was no other advice than to temporarily turn away a large number of patients. At a certain time of the year, the number of registered patients was well over 100. We sought to remedy this inconvenience by

treated the most needy patients first; moreover, there was a reasonable prospect of such an expansion of the institute that all legitimate claims could probably be satisfied. This was made possible by the large grant of 240,000 crowns, which was granted to the institute as an interest-free loan under the Finance Act of 1899-1900, as well as by the finally made possible acquisition of the property in the villa district "Rosenvaenget," already mentioned in the previous annual report, which in every respect, both in terms of its buildings and its grounds, is eminently suitable for the institute.

While the future of the Light Institute seems to be well secured in economic and material terms, it was at the same time important to me to provide the institute with the greatest possible security through a strong internal organization, especially with regard to intellectual resources

Since it is dangerous for any institution to depend exclusively on one person, I sought to avoid this at the Light Institute by giving each department of the institute, the laboratory and the clinic, a completely independent and responsible director. The management of the laboratory has been taken over by my long-time collaborator and friend, Dr. Sophus Bang, whose scientific abilities and critical talent will be of the greatest importance for the Light Institute, and whose task in the coming years will be to take over the leadership of scientific-physiological investigations in the field of light.

The management of the clinic was given to Dr. Holger Forch.

Dr. Bang is currently an assistant physician at the municipal hospital and will therefore not be fully at the service of the Light Institute for another 1.5 years

Hammer, who joined in February 1898, was appointed senior physician at the end of 1899. His administrative talent and practical ability have brought the institute great benefit under often difficult conditions. 2

In this way, the laboratory and the clinic, which were initially united, have been completely separated; however, I hope that the separation will primarily be beneficial and not harmful. Since the two departments will be located next to each other on the same property, and since the head of the institute will form a link between them, the conditions for the necessary cooperation will be favorable. On the other hand, the field of work for both departments is so large and so diverse that the separation was absolutely necessary

As before, the institute has received numerous visits from doctors, some Danish, some foreign. The visits from foreign doctors must be considered of great importance as an excellent means of spreading interest in light treatment; for while the light institute and light treatment had long enjoyed the greatest recognition from Danish and Scandinavian doctors, the same could not be expected from foreign doctors. Indeed, it is not surprising that the medical world received the reports about the remarkable effects of chemical rays with a certain suspicion, whether because they are harmful, as in smallpox, or beneficial, as in lupus. Furthermore, the fact that these things appeared in a small country, distant from the great center of science, and originally in a language known only to a few, was of no small importance.

The visits from foreign doctors were of two kinds::

Some came from doctors who were just passing through Copenhagen and thus took the opportunity to see the Light Institute; others from such doctors, mainly dermatologists, came exclusively for the purpose of the matter itself. The latter stayed for shorter or longer periods of time in order to study the method thoroughly. In this way, we had the honor and the pleasure of receiving several of the greatest and most well-known dermatologists in Europe.

A complete list of the places where the method was introduced and applied is not easy to give; one can only get an approximate overview by looking through the list of places to which the manufacturer of the institute sent light-collecting apparatus. The numbers in parentheses after the name of the city mean that the corresponding number of apparatuses were delivered to doctors or hospitalers.

Athens	London (3)
Baltimore	Moscow
Berlin (2)	Munich
Breslau	New York
Budapest	Paris (2)
Dortmund	St. Petersburg (4)
Hamburg (3)	Washington
Cairo	Vienna (4)
Cologne	

1) During the course of 1899, a change occurred regarding the sale of light-collecting apparatus, in that the firm W. A. Schiörring, Reventlowsgade 10, received a trademark for the apparatus in my name in most countries. Exclusive distribution of the apparatus has since been transferred to the aforementioned firm, while the apparatuses, as before, are manufactured by Mr. Warberg, the plumber. All apparatuses are tested in the Institute's laboratory before shipment

The great interest and favor shown by members of the Danish royal family in the institute and the cause of light have been of the greatest importance for the spread of light treatment and its penetration into certain other European countries. In January 1898, we had the honor of a visit from HRH the Crown Prince for the first time, and later he showed the greatest interest in the Light Institute, its work, and its patients. Since then, the Light Institute has had the honor of being visited several times by members of the royal family and their imperial and royal guests. These visits have had the significance of introducing light treatment to the three countries of Greece, England, and Russia earlier and in a better way than would otherwise have been the case. Her Majesty Queen Olga of Greece donated apparatus for sunlight treatment to the Evangelismos Hospital in Athens and furthermore had a Danish nurse trained at the Light Institute HRH The Princess of Wales donated a complete set of equipment for treatment with sunlight and electric light to the large London Hospital. As a result, the senior physician of the hospital's dermatological department, Dr. Stephen Mackenzie, came to Copenhagen to study the method for about a week. Two nurses were later sent here from the hospital and completed a one-month course.

HRH The Dowager Empress Maria Feodorovna of Russia introduced the method there and made it known to the Russians in the best possible way. Her Majesty wished to establish an institute in St. Petersburg entirely on the model of the local institute and made all resources available so that both a scientific department

(laboratory), as a clinic were established. To convince the medical world in Russia of the importance of the matter, Her Majesty sent the surgeon Prof. Veliaminoff, with his assistant, Dr. Serapine (who now heads the Light Institute in St. Petersburg, assisted by a Danish nurse), to study the method. Furthermore, the Empress summoned Prince Oldenburg (the supreme chief of to Russian medicine) to Copenhagen, along with three Russian von scholars: Prof. Lucianov, Director of the Imperial Pathological Institute in St. Petersburg, Tchistovich, Professor of Infectious Diseases at the Imperial Military Medical Academy, and Dr. Botkin

As a result of these visits, a series of medical lectures were held in St. Petersburg on the light method, some with demonstrations of slides based on photographs from the local institute; several treatises were also written on the subject. In this excellent manner, the light method was introduced in Russia, and as a result, in no other European country, outside Scandinavia, is it as well known and recognized as in Russia.

II. The laboratory of Dr.

Sophus Bang.

Compared to all previous attempts to utilize the properties of light to cure diseases, the effectiveness of the light institute in Institute, is exceptional. II. our 9 Finsen, Medical Light

A special position, which is primarily due to the fact that the institute is based on scientific work in its plan and mode of action. On the basis of scientifically sound theories, Finsen began to use light for curative purposes; no less was the manner in which it was applied, even in the first uncertain attempts, based on physical and physiological experiments. Otherwise, the Light Institute, even with the most successful cures, would not have achieved the leading position it now indisputably occupies in the field of light therapy. Proceeding from this, an ever-increasing interest in both scientific and practical experiments with light has arisen throughout Europe, a movement through which the parent institute in our country perhaps runs the risk of being overshadowed by the institutions already flourishing in many large cities. Admittedly, the Light Institute currently possesses so much fundamental experience that it has a good head start; Whether it will succeed in maintaining its leadership in the future will depend on whether it will also be able to assert its scientific superiority. Fortunately, the importance of this matter was clear to the directors of the institute from the very beginning, as is evident from the first paragraph of the statutes: "The task of the institute is to conduct and promote investigations into the effects of light on living organisms..." To promote these investigations, the institute was divided, as soon as the general status permitted, into an experimental laboratory department and a clinic, each with its own independent director, and ample financial resources were placed at the laboratory's disposal by the institute's management.

A quite significant body of research has been

already done in the laboratory; apart from the results already published, however, a great deal of preliminary work had to be carried out, and on a scale that could not have been foreseen in advance. Although so much has already been written about the effects of light on the animal organism and on bacteria, one very often had to work on previously completely uncultivated ground; only a fraction of the earlier work was carried out in such a way that one could rely on the results. Almost every question had to be addressed from the ground up; not only how to create a light with the desired properties, but also how it should be regulated, controlled, and measured; what properties the applied light had, and what sources of error were inherent in its use—a multitude of such technical details had to be investigated before one could know anything at all about the effects of light. And although we now have much more insight into these circumstances than a few years ago, in many respects we are still aware that we are only at the beginning: everything we have published so far can be regarded only as preliminary work

Of major, as yet unpublished, works that have occupied us over the last two years, we can mention: Investigations into the influence of light on metabolism, with the development of new methods for determining it. The effect of light on tubercle bacilli investigated by means of animal experiments. The effect of concentrated light on living tissues. The influence of light on food substrates. Of smaller works, we can mention: The construction of electrical resistors, particularly suitable for experimental use. Experiments to increase the content of arc light in chemical rays. Light measurements. Investigations into the

Functionality of the equipment used in the clinic. Checking the equipment ordered for export. Microscopic examinations for the clinic. Various bacteriological investigations.

Holger Forchhammer's

clinic.

In 1898 and 1899, as in previous years, the work at the clinic consisted predominantly of the treatment of lupus vulgaris, as the influx of patients with this disease was constantly increasing.

In addition, as space permitted, experiments with the treatment of other skin diseases continued, among which lupus erythematosus, alopecia areata, epithelioma cutaneum, acne vulgaris, acne rosacea, and nevus vascularis planus must be mentioned first and foremost

After the number of light apparatuses was increased from 8 to 16 in November 1897, the number of patients rose very rapidly. While in December 1897 the daily number of individual treatments was less than 50, it had reached 100 by April 1898. A further increase was made possible by the installation of four new light apparatuses in October 1898. For the whole of 1898, the average number of individual treatments per day was 99; for 1899 the number was 126.

The number of new patients admitted was 219 in 1898 and 289 in 1899.

In addition, of those admitted in 1896-97,

88 patients were here for continued or renewed treatment, bringing the total number of patients treated in 1898-99 to 596.

Lupus vulgaris: a total of 454 patients were treated, of which 73 were transferred from 1896-97, 162 were added in 1898, and 219 were added in 1899.

Of the 381 new arrivals, the following were:

males in 1898: 42, 1899: 56, a total of 98; females: 120, 163, 283 „ „

The age of the patients was:

0-15 years: . . . . 1898: 15, 1899: 26, a total of 41

15-25: „ . . . . „ 64, „ 66 „ „ 130

25-40 52, „ . . . . „ 72,,, „ 124

40-60 23, ... „ 48, „ 71 „ „

60-70 " . . . . „ 7,, „ " 15

From Denmark were 1898: 155, 1899: 187, total: 342

From abroad were 7, 32, „ 39 „ „

From the Danes were:

from Copenhagen . . . 1898: 33, 1899: 31, total: 64

„ and the rest of Zealand 18, „ 26, 44 „ „

„ Jutland . . . . „ 81, „ 11, „ „ 182

„ Funen . . . . „ and and 12 „ 14, 26

„ other islands II, . „ 15, „ 26 „

Of the foreigners were:

from Schleswig . . . . 1898: 3, 1899: 9, in total: 12

„ rest of Germany . „ 1, „ 1, „ „ 2

„ Sweden 3, 9 . . . . „ „ 6, „ „

„ Norway 7, 7 " . . . . „ —, „ „

„ Russia 3, 3 . . . . „ —, „ „ „

„ Finland . . . . „ —, „ 2, 2 „

„ England . . . . „ —, „ 3, 3 „ 19

France " 1, ... —, „ „ 1

The duration of the patients' illness before treatment was as follows:

0-5 years	. . . . .								1898: 34, 1899: 67, total: 101	
5—10	„			45,	„	50,				95
10—15	„	„	34,	„	45,		„	79		
15—20	„	„	24,		21,	„		45		
20—25	„	„	13,		20,	„	„	33		
25—30	„	„	4, 5,		11		„			
30—35	„	„	3,	„	5, 8		„			
35—40	„	„		„	1, 4,		„	5		
over 40	. . . . .	„	" 2,	„	2, 4		„			

Of all 454 patients treated for lupus vulgaris, 121 were still under continuous treatment at the end of 1899, 307 had "finished the main treatment," while 26 had discontinued treatment at an inopportune time.

Of the 26 who discontinued treatment, 10 had died (7 from pulmonary tuberculosis, 1 from canker sore ulcer in lupus, 1 from pneumonia, 1 after a laparotomy), 5 stopped because of pulmonary tuberculosis gravis, 5 had to leave due to personal circumstances unrelated to treatment, 4 left us to continue the light treatment at home, and finally, 2 stayed away without giving a reason

While lupus patients had been treated exclusively with light in previous years, in 1898-99 we used various other treatment methods as preparatory or supportive measures in some cases. Thus, we performed scraping or thermocautery in individual cases. More frequently, caustic ointments, usually Ungv. ac. pyrogallici comp. (Besnjer), were used. During light treatment, almost all patients wore a protective

dressing, either a compress of boric water or an indifferent ointment.

The numerous mucosal locations, which were largely inaccessible to light treatment, required special treatment

Mygind did the institute the service of examining 200 of the patients and kindly undertook the treatment of the incident cases of lupus laryngis from Prof. Holger.

The frequently occurring eye diseases are kindly treated at the Eye Diseases Clinic of the Municipal Hospital (Dr. med. Ejler Hansen and Dr. med. CHR. F. Bentzen).

Other complications often required special treatment, and the institute's physicians occasionally supervised the patients at home. We also exercised a certain degree of supervision over the larger and smaller boarding schools established specifically for the institute's patients.

Erysipelas and erysipelas-like cases have occasionally occurred, but only as isolated cases.

No diseases have occurred epidemically among the patients.

As before, Prof. Haslund kindly helped to make the diagnosis in doubtful cases.

Finally, it must be mentioned that some of the institute's lupus patients were kindly treated by Dr. Johan Fischer, partly in the Municipal Hospital, partly in his private clinic

Other diseases: In the years 1898-99, a total of 142 patients with other diseases were treated. Of these, 15 were transferred from 1896-97, 57 came in 1898, and 70 in 1899.

1. Lupus erythematosus: a total of 31 patients,

27 of them from Denmark, 2 from Russia, 1 from Norway, and 1 from Sweden.

Of the patients, 7 were men and 24 women, all over 25 years old.

At the end of the year, 11 were apparently cured, 10 were still under treatment, while 10 had discontinued treatment without result. Of the latter, one died with a sharp increase in the extensive suffering, one worsened significantly under treatment, and the others were only slightly affected.

The majority of the patients were treated exclusively with light; some were also treated simultaneously with other methods, most frequently with superficial galvanic cauterization.

2. Alopecia areata: a total of 29 patients, all from Denmark.

18 males, 11 females
Age: 0-15 years: 8 15-25
25-40 „
40-60 9 8 „
4

At the end of the year, 22 were cured, 1 was still under treatment, while 6 had discontinued without result, most after a treatment of only a few séances.

Almost all patients were also treated with antiseptic bath waters during the light treatment.

3. Epithelioma cutaneum: a total of 17 patients, all from Denmark.

Males: 7, females: 10. Age: 25-40 years: 1 40-60 7 60-80 9 9

At the end of the year, 8 were apparently cured, 2 were in marked improvement, and 7 had discontinued treatment. Of these, one had been treated for a long time under the diagnosis of lupus vulgaris. The large cancerous ulcer healed, but the condition quickly worsened again. One improved but died of an intercurrent illness. One was treated solaminis causa for a large facial ulcer.

4. Acne vulgaris and acne rosacea: a total of 15 patients, of whom 14 were from Denmark and 1 from Norway.

Males: 8, females: 7. Age: 14-25 years: 6, 25-40, 40-60, 5, 4

„
„

At the end of the year, 4 were apparently cured, 5 were significantly better, and 1 was still under treatment, while 5 had discontinued treatment without result

5. Naevus vascularis planus: a total of 10 patients, of whom 9 were from Denmark and 1 from Norway.

3 males, 7 females. Age: 0-15 years: 4, 15-25, 25-40, 3, 3

„

At the end of the year, one was apparently cured, 2 had discontinued treatment, and 7 were still under treatment.

6. Tuberculosis cutanea: a total of 7 patients: 1 ulcer of the tuberculus anguli oris, still under treatment; 3 cases of verrucose tuberculosis, of which 2 were cured, the third concluded without result; 3 cases of scrofulous gommages, which were not noticeably affected by the light treatment

7. Trichophytia capitis: a total of 6 patients, all children under 7 years of age.

The result was negative in 4 cases; in 2 cases, both recent and only slightly spread, recovery occurred.

8. Favus, 2 cases, both with negative results.

9. Seborrhoea capitis, 4 cases, all with negative results.

10. Eczema faciei and sycosis, 5 cases, all with negative results.

11. Ulcera luetica, 5 cases. The 2 cases that were treated for some time under a false diagnosis apparently improved; the other 3 cases were treated only for a short time and primarily for social reasons.

12. Keloid after vaccination, 1 case in a 6-year-old child; treated with negative results.

13. Pigment atrophy, 2 cases, with negative results

14. Various, a total of 8 cases of other illnesses where treatment was not fully completed. Among them was one case of chronic otitis and one case of urinary vesicle tuberculosis, treated using specially constructed apparatus, both without a clear result.

VI.

Investigations into the frequency of lupus vulgaris in Denmark

by Prof. Dr. N. R. Finsen.

Since, due to the large and continuous influx of lupus patients to the Light Institute, it would be advantageous for practical reasons to know the number of local lupus patients, we have undertaken to provide some clarification on this matter

In view of the scientific interest that such a study would have, we initially wanted to make it reasonably comprehensive; however, it soon became clear to me that the difficulties were so great, and the prospects of obtaining a reliable result so slim (a point I will demonstrate below), that I decided not to make the study more comprehensive than necessary for our practical purpose.

To obtain information about the number of local lupus patients, two approaches were possible: an inquiry to all physicians or to all pastors. If the first approach was chosen, the result would be highly inaccurate, for it is a fact that most lupus patients with long-standing lupus no longer seek medical help for their illness and are therefore not treated by physicians

are known. If the doctors had a specific topographical sphere of influence and knew all the people within this sphere, the ratio would be quite different. The latter applies better to the pastors, but on the other hand, there is the inconvenience that one cannot rely on the diagnosis. To obtain scientific, usable statistics, the pastors and doctors would have to work together, so that the pastors would locate the sick and the doctors would make the diagnosis. However, this question was not of such great importance to me that I should initiate such a large project and inconvenience so many people. On the other hand, it would be worthwhile to try this combined method of investigation in a limited number of pastorates, then to be content with that, and to draw a conclusion about the situation in the entire country from the resulting ratio

—

It was fortunate that some time before, the Light Institute had received a visit from a large number of pastors from various parts of the country who had come to Copenhagen for other reasons. In the hope that their visit had interested them in the matter and that they would therefore conduct careful research, we sent these pastors, as well as many personally acquainted ones—a total of 70 pastors[1]—a form to be filled out, in which the following questions were asked: 1) How many patients (names, ages) suffering from facial lupus are in the pastorate? 2) Has the diagnosis been made by a doctor?

65 pastors answered these questions, and the result was the following: In 31 pastors, there were no lupus

1) We chose almost exclusively pastors from rural pastorates, as they were probably much more likely to know all the residents of the pastorates than the pastors from the cities.

patients, in the remaining 34 there were 54 patients, and these were distributed as follows:

in	2	pastorates	4 patients
„	2	„	3 „
„	10	„	2 „
„	20	„	1 „

The diagnosis had been made by a doctor in all cases, except for two. All the answers, for which I hereby express my sincere thanks, proved that the pastors had made great efforts to obtain precise information, and in many cases they had cooperated with doctors to find patients.

These investigations were conducted in March and April 1899.

Since I would like to have an expert opinion on the value that could be attached to these investigations, I turned to the State Statistical Bureau, and Director Rubin took up this matter with the greatest graciousness. He had the information collected examined and sent me the following statement on the result, with permission to use it:

"To shed light on the question of the number of local lupus patients, you collected some information from several clergymen in the countryside and asked me to what extent I believed that one could draw a conclusion about the whole from these scattered information.

Although a procedure such as the one you used can produce useful results, the material in the present case is too small and does not provide enough information on important points to be given any value. Nevertheless, I have made the calculation you requested, but after our discussion, we agree that it not only has no

scientific value, but that one should not, or even less, rely too much on it for practical use.

Of the 65 schemes sent, I eliminated 2, some of which concern cities (one with 0, the other with 2 patients), and I then distributed the remaining 63 as follows:

Number of rural pastorates surveyed		Number of patients	The number should be in proportion to the total
Zealand (including Bornholm)	12	10	10
Funen, Laaland-Falster	16	12	13
Jutland	35	30	29
Total:	63	52	52

The distribution is therefore fairly even, and the number of patients should therefore be 82.5 percent of the number of pastorates. There are currently approximately 1,000 rural pastorates, but since some of these are connected to a city or a trading center, the most correct estimate regarding the rural population alone is to count with approximately 950, and the number of lupus patients should then be 784

Since we have separated the rural population from the urban population here, the former can only be counted as part of the population of Denmark as a whole, and if you accept the 784 and assume that a corresponding ratio can be applied to the urban population, we obtain, as far as the latter is concerned, 523 patients. On the whole, your material, used in this way, should lead us to estimate the number of lupus patients in Denmark at approximately 1,300.

Although Director Rubin's judgment on the result

is so hopeless that it might seem most correct to leave the question alone, I will nevertheless add a few remarks and clarifications. The question is of the nature that it is impossible to obtain exact figures and a reliable result, but therefore one must not completely give up the attempt to get as close to the truth as possible.

The question here is whether the number 1,300 (approx. 1/2 per mille) is too large or too small. I must leave aside the two important questions: 1. whether the number of lupus patients was disproportionately large or disproportionately small in the pastorates studied, and 2. whether the incidence of lupus differs among the urban population and the rural population. However, I will point out that the number of lupus patients given for the 65 pastorates is definitely a minimum, since these are patients known by name and the diagnosis was made by doctors

While, as far as I know, no studies or clarifications on this question have been available from other countries, the recently (1900) published 30th to 31st volume of NEISSER'S: Stereoscopic Medical Atlas contains some studies by Prof. NEISSER on the frequency of lupus in Silesia in the preface, page VI.

Prof. NEISSER writes about this: "I can provide the following information on the frequency of lupus in Silesia (with almost 42 million inhabitants): I wrote to the 1,560 physicians in Silesia asking them to report all lupus cases known to them. Replies were received from only 1,060 physicians, reporting 709 lupus cases. It is not necessary to explain in detail that this number in no way reaches the number of lupus cases present in Silesia. Apart from the fact that over-

Since only two-thirds of the doctors responded, many lupus cases in the area in which they practiced will also have remained unknown to those who wanted to fulfill my inquiry.

If one now assumes that the doctors who did not respond could report a corresponding number of lupus patients, one would obtain the result that there are at least approximately 950 lupus patients among Silesia's 4.5 million inhabitants, i.e. barely 14 per thousand, while my number for Denmark was at least 1/2 per thousand.

Despite this large difference, one should not conclude that lupus is more common in Denmark than in Silesia, because, as I emphasized above, one will always receive a much too small number when inquiries are made to doctors

However, if we disregard these problematic figures and stick to what is available of a more reliable nature, we will see that the number of lupus patients from Denmark alone, for which we have already reported at the Light Institute, is greater than 14 per 1,000 (so far we have treated a total of 477 lupus patients from Denmark, plus 192 who were or still are registered.

If I add that the registration of new patients (but old cases) is still very high, it is hardly an exaggeration to conclude 1) that the remaining

1) Since there are now so many factors that can influence the number of registrations, one must be somewhat cautious about drawing conclusions from them. From the establishment of the institute, there was a constant and fairly uniform increase in the number of patient registrations until the first quarter of 1899. This was followed by a quiet, slow decline. In recent months, there has been some increase again, without, however, reaching the number of the first quarter of 1899.

The number of lupus patients in this country is not entirely small, and it will perhaps turn out that the main number that emerged from our investigations is not far from the correct one

The result of Prof. Neisser's extensive work, which cost both a great deal of money and time, is undoubtedly even smaller and even further from the truth than ours, and does not encourage similar comprehensive investigations here, especially since in a few years, if everything goes as it has so far, we will receive excellent statistical material on the frequency of lupus diseases in this country from the Light Institute.

When we conducted the investigations mentioned here, we had no idea of the frequency of lupus disease; when speaking with doctors, one could hear assumptions that varied from 500 to 5,000 cases, and if the uncertainty was so great, one must assume that something has been gained from our investigations,

VII.

Treatment of measles and scarlet fever with exclusion of so-called chemical light rays.

Review article by Valdemar

Bie.

In an article 1) on the treatment of smallpox with exclusion of chemical light rays, Finsen wrote the following:

"This treatment, however, is, as one can see, not specific for smallpox; it is a new therapeutic principle which, as I have already stated above, could possibly acquire a certain significance in other exanthematous diseases and skin diseases. In any case, it will be of great interest to gain clarity on the question of whether chemical rays have an influence on these diseases or not. Skin diseases are a special matter; on the other hand, such investigations in exanthematous diseases, e.g., measles, scarlet fever, and erysipelas, would be very easy to conduct and, moreover, would be completely harmless." "Such experiments could easily be carried out in any hospital for infectious diseases, e.g., by lighting a sickroom with red light and an-

1) N. R. FINSEN: On the harmful effect of chemical rays on the animal organism. Hospitalstidende No. 44, 1893.

illuminated with ordinary light and then observed to see whether there is a difference in the course of the disease; one could also hang red curtains over the windows for a few days and then allow the light to enter again in the usual way over the next few days." Since it is now established that the exclusion of chemical light rays definitely prevents suppuration in the smallpox blisters, it seems to me time to try treating other exanthematous infectious diseases with red light as well, and this all the more so since animal pathology knows of a general disease accompanied by exanthema that is dependent on light. When ruminants are fed buckwheat, the white animals exposed to the light develop symptoms of poisoning from a narcotic substance, as well as a vesicular skin eruption; the white animals kept in the dark, as well as the black animals, remain healthy

Of course, one cannot draw any conclusions about the influence of light on the course of other exanthematous infectious diseases either from the circumstances of this buckwheat disease or from the favorable results of smallpox treatment with red light; however, it seems to me that the experiences mentioned justify the attempt to apply Finsen's treatment method to these diseases as well. So far, this has only been done on a limited scale, with only seven series of experiments available.

Immediately after Svendsen published the first favorable results of smallpox treatment according to Finsen's method in Bergen, the district physician Birkerod tried treatment with red light in two scarlatina-like cases.

1) F. Birkerod: Reports from the Municipal Hospital in Nyborg. Ugeskrift for Läger 1894. p. 211. 10*

In both cases, the patients became free of fever a few days after being exposed to red light, even though no antipyretic was used at the same time, and even though quinine, antifebrine, and antipyrine had no effect on any of the patients. Dr. Birkerood, on the other hand, mentions no effect on the scarlatina-like rash that was present in both cases.

The question of the effect of red light treatment on temperature is very interesting, but it has not yet been the subject of any thorough experimental or clinical investigation. This question cannot be resolved by two cases, as Dr. Birkerood himself quite correctly saw, noting that one cannot draw any conclusions from these individual experiments, but that the favorable result nevertheless encourages the continuation of the experiments

THYMANN,1 who attempted to treat scarlatina patients with red light in the Copenhagen District Hospital, had a much better opportunity than BIRKEROD to assess the effect of red light on the course of the disease, insofar as he had 36 patients at his disposal. However, he focused his attention entirely one-sidedly on the course of the exanthem. He writes the following about his experiments: "36 patients (with scarlatina, Ref.) were treated with 'red light' at Finsen's instigation. As far as one could judge, the red light did not have the slightest effect on the intensity or duration of the exanthem, since no effect could be observed on either strong or weak exanthems. The initially relatively weak and pale exanthems spread undisturbed and later became very

1) F. THYMANN; Diphtheria and Scarlet Fever, etc. Hospital Year 1895. p. 270

intensive; the initially relatively severe exanthems did not fade any faster with this treatment, but the red light seemed to have a calming effect on several patients

Whether treatment with red light has a beneficial effect on the exanthema does not seem to me to be the most important issue, since this exanthema as such poses no danger to the patient; at most, such an effect would shorten the exfoliation and, consequently, the isolation. The main thing is whether this treatment has an influence on the course of the infection itself and on the other reactions of the organism; in particular, one must observe temperature, pulse, general condition, and cerebral functions (delirium, coma). If Thymann's impression that red light has a calming effect on patients was confirmed in repeated experiments, this is of far greater value than a beneficial effect on the exanthema, whether that a milder course of the disease or that the minimal exposure to light on the retina is the reason for the calming effect

Later, E. Schouli 1) tried the effect of red light on two cases of scarlatina, after having achieved excellent results in the treatment of smallpox using this method. Desquamation was not observed in any of the cases.

Festner (Riesa) informed me in a letter that he had used red light treatment on a case of scarlet fever. When the patient (a 14-year-old girl) was placed in red light, she had angina, 40.5° C, and lobster-red skin; 24 hours later, the fever had disappeared, her general condition was good, and the patient had an appetite; only her pulse remained at 110 to 106 for about four days.

1) E. Schouli (Tunis): Société de thérapeutique de Paris, October 11, 1899. Ref.: Zeitschr. f. dietetic and physical therapy, 3rd vol., p. 612

Th. Schüler in Berlin informs me that he has treated 26 cases of measles and 14 cases of scarlet fever with red light. In all cases, he had the impression that the treatment had a highly calming effect, even at a temperature of 40°C and above, as well as that the itching was less severe and that the exanthema and conjunctivitis disappeared more quickly.

Provincial doctor Backmann1 in Viborg (Finland) gave a brief report in his article "On Variola Vera and the Chemical Exanthema" that he had also found Finsen's method effective against other acute exanthematous infectious diseases, e.g., scarlet fever and morbilli. I wrote to Dr. Backmann for further clarification, and he sent me the following reply, for which I express my sincere thanks:

"Only 5 or 6 cases of scarlatina occurred at the hospital at that time (i.e., during the four years when Dr. Backmann was employed as a physician at the epidemic hospital in Kolikkomäki) and were treated using the same method. The exanthema was weaker and the desquamation followed more quickly, the fever disappeared within 48 hours, brain symptoms were hardly noticeable, and convalescence was faster. I could not perceive any influence of the method on the throat symptoms. After four years, the epidemic hospital was closed, but I always used Finsen's method in my private practice and derived much benefit from it, especially in the hundreds of morbilli cases I treated. The fever was always slight and of short duration, the catarrhal eye and lung affections were slight and

1) HERMAN BACKMANN: Finnish Medical Handling Manual, Vol. 50 No. 5, May 1898, p. 486.

No brain symptoms occurred. Therefore, I was particularly satisfied with the method, and the parents of the patients no less so; I intend to continually follow this good and practical method of treatment. As the provincial physician of a large district (6 municipalities with approximately 100,000 people), I have not been able to keep a journal or make notes on all the illnesses, but I can state with conviction and experience that Finsen's method is of great and real importance in the treatment of exanthematous illnesses, whose course becomes milder and more rapid.

One can rightly object to Backmann's favorable impression of Finsen's method of treatment that it is entirely subjective and, as far as scarlatina is concerned, is certainly based on too little material

Chatinière, meanwhile, conducted some experiments with treating measles with red light during a widespread and typical measles epidemic, which fortunately supplemented Backmann's observations. Chatinière happened to conduct a kind of control experiment (Case No. 1), i.e., he let the patient lie alternately in red light and in full daylight, just as Finsen suggested in the passage cited above. The value of Chatinière's experiment is further increased by the fact that he did not expect to obtain favorable results from the outset, but tried this method of treatment "par simple curiosité." ChatiniÉre appears to have thoroughly excluded chemical light rays; however, he does not mention a spectroscopic examination. The first case history is so interesting that it deserves to be reported in extenso:

1) CHATINIÈRE: La Presse médicale, 10 September 1898, No. 75, p. 78

No. 1. "V. V., 8 years old, suddenly developed a headache and fever on the evening of July 19th. I was called; I diagnosed significant gastric disturbance, and since the child was predisposed to this, I prescribed a poultice. Two hours later, during which the child sweated profusely, an almost general eruption (head and body) of an undoubted nature appeared. There was photophobia, a cold, and a rough cough; the temperature was 39°C; all of this developed quite suddenly. I prescribed a sedative and a mustard poultice around the lower legs. The following morning at 9 o'clock the eruption was more pronounced, the eyes were red and swollen; there was loud wheezing, and the temperature had not fallen (39.3°C)."

I then advise covering the windows and doors with a red calico curtain, without any deeper conviction, merely out of curiosity. At noon, I go to the patient to see how my order has been carried out, and I note to my surprise that the eruption has completely disappeared; furthermore, the child, who is now afebrile, has become cheerful, even too noisy; he complains of not being able to see his toys. I then allow the parents, who cannot bear the patient's complaints, to remove the red curtains

Around 3 o'clock, the mother asks me to come quickly: the eruption has returned in its full extent; the fever and dullness have also returned. They ask if there are complications. I reassure the parents, have the red curtains hung up again, and give the order not to take them down again. After two hours, the eruption had disappeared, and the general condition was better. Shortly afterward, the cough and photophobia subsided. In short, within 48 hours the illness was over, and the child was convalescing; during the

desquamation, nothing was noticeable. After 8 days, the patient was given a bath and went out, and this case of measles, which initially looked so threatening, has on the whole progressed as calmly as possible from the moment the light was excluded

No. II was a 12-year-old brother of the previous child. He developed the usual initial symptoms. "Right at the beginning of the illness, the above-mentioned treatment was applied, and despite the intensity of the premonitory symptoms and the child's constitutional weakness, the measles ran its course in two days; the eruption lasted barely 12 hours. The child got up, had a bath, and went out on the sixth day without having experienced the slightest complication. The catarrh of the conjunctiva, nose, and larynx was minimal, without any medical treatment being employed."

No. III, a 5-year-old child, was ill for only four days; there was neither desquamation nor complication. The child got up, had a bath, and went out on the sixth day

No. IV, sister of the first two patients, was placed in the red light before any skin symptoms appeared. The entire course of the illness lasted barely three days. Whether an exanthema developed during the stay in the red light is not mentioned; the case history is very brief and summarized in a postscript.

Case histories Nos. II, III, and IV, taken individually, actually prove nothing other than that there are cases of measles that progress mildly and quickly, despite the presence of severe premonitory symptoms. More valuable is No. I, where the exclusion of the chemical light rays caused the severe symptoms (severe exanthema, Type 3913, dullness) to disappear within three hours

where these symptoms returned three hours after the red curtains had been removed, only to disappear again within two hours after the red curtains had been hung up again. If a sufficient number of such control experiments had produced the same result, they would have been definite proof of the excellent effect of treating measles with red light. This single experiment cannot, of course, be considered proof, but this and the three other cases of Chatiniere, in conjunction with the favorable impression made by Backmann and Schüler of the measles cases they treated, indicate enough that treatment with red light has a favorable influence on the course of this disease to give reason to continue the experiments

Attempts to treat other exanthematous infectious diseases, apart from — smallpox, with red light have not progressed further than that one must begin almost from scratch. This method of treatment must be attempted for these diseases as well, all the more so as it is completely harmless, not unpleasant for the patient, and easy to carry out even in private practice.

* New Publishers of F. C. W. Vogel in Leipzig. *

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